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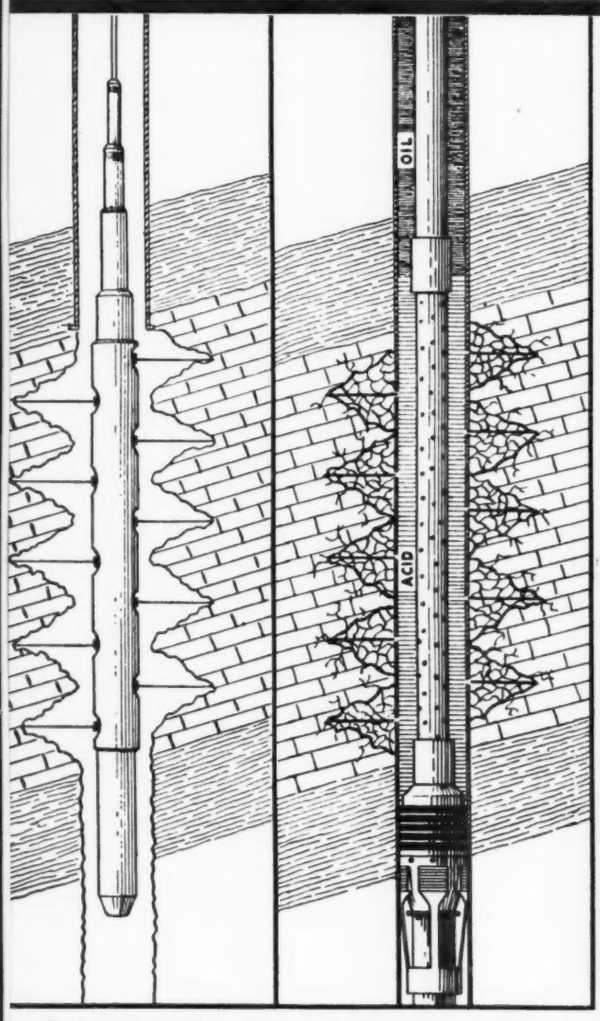

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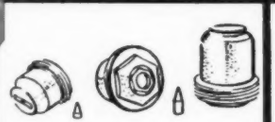

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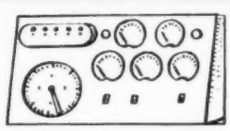

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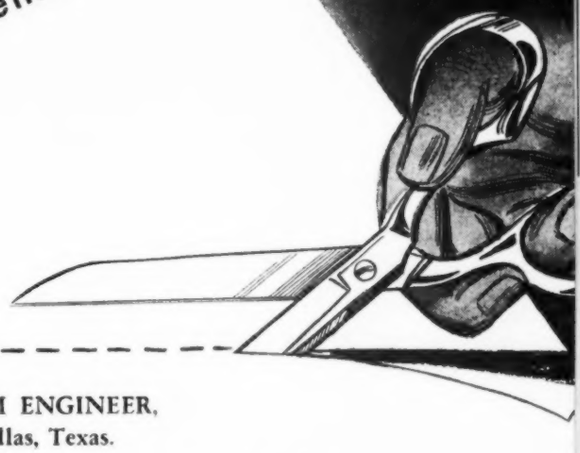

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THE Petroleum Engineer

MAY 1938

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MEETINGS

International Petroleum Exposition—May 14, 15, 16, 17, 18, 19, 20, and 21, Tulsa, Oklahoma.

•

American Petroleum Institute, Eighth Mid-Year Meeting — May 23, 24, and 25, Wichita, Kansas.

•

Pennsylvania Grade Crude Oil Association and Pennsylvania Natural Gas Men's Association, Seventh Annual Petroleum and Natural Gas Conference—May 27 and 28, Pennsylvania State College, State College, Pennsylvania.

•

Society of Automotive Engineers, Summer Meeting—June 12, 13, 14, 15, 16, and 17, White Sulphur Springs, West Virginia.

•

American Society of Mechanical Engineers, National Oil and Gas Power Meeting—June 15, 16, 17, and 18, Dallas, Texas.

•

Pennsylvania Grade Crude Oil Association — June 16, 17, and 18, Pittsburgh, Pennsylvania.

•

American Society of Mechanical Engineers—June 20, 21, 22, 23, and 24, St. Louis, Missouri.

•

American Society for Testing Materials, Annual Meeting—June 27, 28, 29, 30, and July 1, Atlantic City, New Jersey.

•

American Chemical Society—September 5, 6, 7, 8, and 9, Milwaukee, Wisconsin.

•

American Petroleum Institute, 19th Annual Meeting—November 14, 15, 16, 17, and 18, Stevens Hotel, Chicago, Illinois.

THE PETROLEUM ENGINEER PUBLISHING COMPANY

Seventh Floor Allen Building DALLAS, TEXAS Telephone: 2-4571

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The Course of Oil

By K. C. SCLATER

A Desperate Situation Better control within the industry is sadly needed. Current excess crude production and burdensome inventories of refined products are evidence of a lack of control. This unhealthy state of affairs might have been averted had effective means of control been available within the industry itself. One of the reasons why such control is absent is that the expressed attitude of the Federal Government has discouraged the industry from engaging in constructive attempts to balance the supply of its products with the demand. It is this impotence of the industry to correct its own economic ills that is largely responsible for its present plight.

The oil industry, it would seem, must look to some agency outside itself for aid. It may be that the effective control necessary to maintain supply and demand in economic balance must come through State regulation. Should this be so, the Interstate Compact Commission is destined to play a significant role. As a forum for a frank consideration of vital problems and their solution, it has an opportunity of extending greatly its scope of activity and usefulness. If it can act to set the machinery in motion that will bring about desirable changes in State regulations of mutual benefit to the State and the industry, it will justify the confidence of the public and the entire oil industry. It is in a position to render an important and valuable service by helping to establish through State agencies that sound economic control which the industry now lacks.

Growth of Vocational Training Vocational training in any industry requires the support of organized groups in that industry. In this respect the petroleum industry is particularly fortunate. Vocational training has had the wholehearted support of oil companies and the valuable cooperation of the American Petroleum Institute. This is one reason why vocational training has been so eminently successful in the petroleum industry. The records show that only two percent of the students drop out through lack of interest.

Courses are designed specifically for workers in the petroleum industry. During the few years that vocational training has been in effect attendance at classes and the number of courses given have shown remarkable growth. New courses are continually being requested by men in the field. It is found that compulsion is one factor that militates against the success of the classes. Attendance is purely voluntary.

Since the spring of 1933 when classes were organized more than 12,000 men in Texas alone have been enrolled in 684 classes in 91 different centers. A total of 34 different subjects were offered, and mathematics was the most popular course given.

This interest in vocational training among field employees is significant and encouraging. Its economic value to the industry, though intangible, is great.

International Petroleum Exposition Few oil men visit the International Petroleum Exposition at Tulsa, no matter how many previous expositions they may have attended, without coming away amazed and overwhelmed at the infinite variety of products on display. They marvel at the many different types of equipment used in all branches of the industry. The exhibits on display run the gamut from the heaviest types of machinery to the most delicate instruments of the utmost precision.

Each Exposition is the occasion for exhibiting new types of equipment recently developed. There seems no end to the inventive skill lavished on the design of machinery and tools to meet new needs and improve present practice. Practically all the equipment on display has been designed and developed since the birth of the oil industry in the United States less than eighty years ago.

The Exposition this year promises to surpass those of other years as a means of keeping abreast of the latest developments in equipment used in all branches of the petroleum industry.

Metering Crude Oil Accurate volumetric measurement of crude oil by meters is now under investigation by many engineers in all branches of the industry. The volumetric measurement of "live" crude oil, that is, oil containing gas in solution, is one that is difficult of general application. Crude oil as it comes from the well under pressure contains gas in solution. This interferes with the accuracy of the measurement.

The degree of accuracy required in the measurement of crude oil is one point on which there is a great divergence of opinion. The purpose of the measurement must be taken into consideration. Further investigation by meter manufacturers and by users of meters will be necessary on this phase of the metering problem. A free interchange of information between the manufacturer and the meter user should exist.

Important changes in the methods of measuring crude oil are in the offing and great growth in the use of meters is predicted. In the production of oil from great depths the conservation of energy and the elimination of sources of loss become imperative. Stabilization of crude at the well has been introduced in recent years as a means of energy conservation and reduction of evaporation losses between the well and the refinery. Most of the prolific fields of the future will be deep and will emphasize the need for closed systems for handling production at the well and during transportation to the refinery.

The first Liquid Metering Conference held at Norman, Oklahoma, last month, the attendance and eager interest displayed there, were evidence that the next few years are likely to witness important developments in the metering of crude oil.

« « HIGHLIGHTS IN OILDOM » »

Illinois Pipe Lines Limit Takings

The Owensboro Pipe Line Company and the Illinois Pipe Line Company have limited their takings of crude oil from the Centralia field of Illinois to 20 bbl. per well per day. This is the first time in the history of the oil industry in the state that pipe-line proration has been invoked to reduce production. Under this proration, production of the Centralia field has been reduced to 2180 bbl. per day from 109 producing wells.

William Bell, Robinson, Illinois, member of the Interstate Compact Commission for Illinois, has stated that inauguration of pipe-line proration may result in the passage of an oil and gas conservation law for the state. Heretofore, the state has had no need for such a law, as proration of production was unnecessary, according to operators; however, new development in the basin area and intensive drilling in the Centralia townsite have resulted in an output of oil that pipe lines have been unable to transport.

●

Increase in Venezuelan Crude Output

Venezuela's production of crude oil during March showed a slight increase over February's output, as well as over March, 1937. In March leading companies produced 14,776,000 bbl., a daily average of 477,000 bbl., compared with 13,588,489 bbl. in February, and 14,707,000 bbl., or a daily average of 474,000 bbl., in March, 1937. For the first three months of this year output totaled 42,569,000 bbl. as against 36,552,000 for the similar period of 1937, an increase of about 16 percent.

In the shipping fields of Venezuela 68 wells were completed in March. Venezuelan Oil Concessions completed 25, Creole 16, Mene-Grande-Gulf 12, Lago nine, Caribbean four, and Colon two. Forty-three strings of tools were drilling in the shipping fields at the end of the month, and in addition there were several wildcat tests being drilled.

●

Appeals Pennsylvania Probe Ruling

Attorney General Charles J. Margiotti has appealed the recent decision of the Dauphin County Court, which held invalid the legislative inquiry into the petroleum industry. The attorney general stated he would ask the lower court to allow the appeal to act as a supersedeas in order to make it possible for the commission to continue its work while the constitutionality of its acts are being determined.

●

Ask 40-Acre Spacing in Deep Fox Area

Skelly Oil Company, Carter Oil Company, and Phillips Petroleum Company have petitioned the Oklahoma Corporation Commission for a 40-acre spacing program for the deep Fox area. In the petition it is pointed out that expense of development in the area is exceptionally high because of depth of wells and the hard drilling formations. The cost of completing a well is said to exceed $180,000. Furthermore, indicated recovery is only 10,000 bbl. per acre. These factors result in a return per acre of less than normal when the wells are spaced closer than one to 40 acres, it is stated.

●

Rules for Mirando and Slaughter

Rules for wells producing from the 1800-ft. sand in the Mirando Valley field, Zapata County, Texas, have been issued by the Railroad Commission. The regulations permit drilling of five wells on 40 acres, one on each corner and one in the center. Wells must be at least 600 ft. apart and no well may be drilled closer to a lease line than 300 feet. Thirty-five ft. of surface casing cemented to the surface is required and the oil string must be cemented high enough to protect the 1500-ft. sand. Proration will be on a per-well basis.

The commission has entered a temporary spacing rule for the Slaughter field, Hockley County, pending a hearing to be held May 16th. The temporary rule is for wells to be spaced 1240 ft. apart and 400 ft. from lease lines.

●

City Loses Gas Stabilization Suit

The City of Fort Worth, Texas, has failed in its effort to prevent the Lone Star Gas Company from serving consumers with gas from its Joshua stabilization plant. The United States Supreme Court, on April 25, denied an application for a review of the case.

The high court refused to pass upon a decision of the Fifth Circuit Court of Appeals, which held the Fort Worth ordinance prohibiting addition of nitrogen or other inerts to the gas was unreasonable and arbitrary. The Lone Star Gas Company originally brought suit against the ordinance, explaining it was necessary to reduce heat value of gas from West Texas to make it safely interchangeable with gas from other fields. Losing the decision of the appeals court the City of Fort Worth appealed to the Supreme Court.

●

Tanker Construction Shows Slight Increase

At the end of March, according to a report of Lloyd's Register of Shipping, the number of steam- and motor-driven tankers of 1000 tons gross and more under construction in the world was 105, totaling 865,167 tons. Of this total, 31 vessels, having a total tonnage of 244,657, were being built in Great Britain and Ireland; 16, of 138,826 tons, in Germany; 16, of 118,390 tons, in Holland; 13, of 104,650 tons, in Italy; 11, of 92,009 tons, in the United States; six, of 70,625 tons, in Japan; and four, of 37,700 tons, in Sweden. Of these, 86 vessels having a total tonnage of 722,328 were motor vessels.

At the end of the preceding quarter the world total was 97 vessels having a gross tonnage of 768,931.

●

Roumanian Officials to Encourage Oil Exploration

Government officials in Roumania are taking active steps to encourage prospecting for oil in the country with the hope of discovering new fields. Old fields are being depleted rapidly and existing mining laws are such as not to encourage wildcatting. It is estimated that 2,500,000 acres may be oil-bearing.

When C. Argentoianu became Minister of Commerce and Industry he made a study of conditions, consulting on numerous occasions with representatives of the oil industry. He stated following his investigations that, in his opinion, two things were desirable:

"1. Rational exploitation of the fields at present being produced, or those which will be put into production in the near future. This exploitation has been carried out in the past on unscientific lines, with the result that with the decreasing gas pressures (the gas having been in some cases blown into the air), half of the oil which could have been extracted has remained forever unrecovered in the ground.

"2. That immediate steps be taken to carry out prospect-

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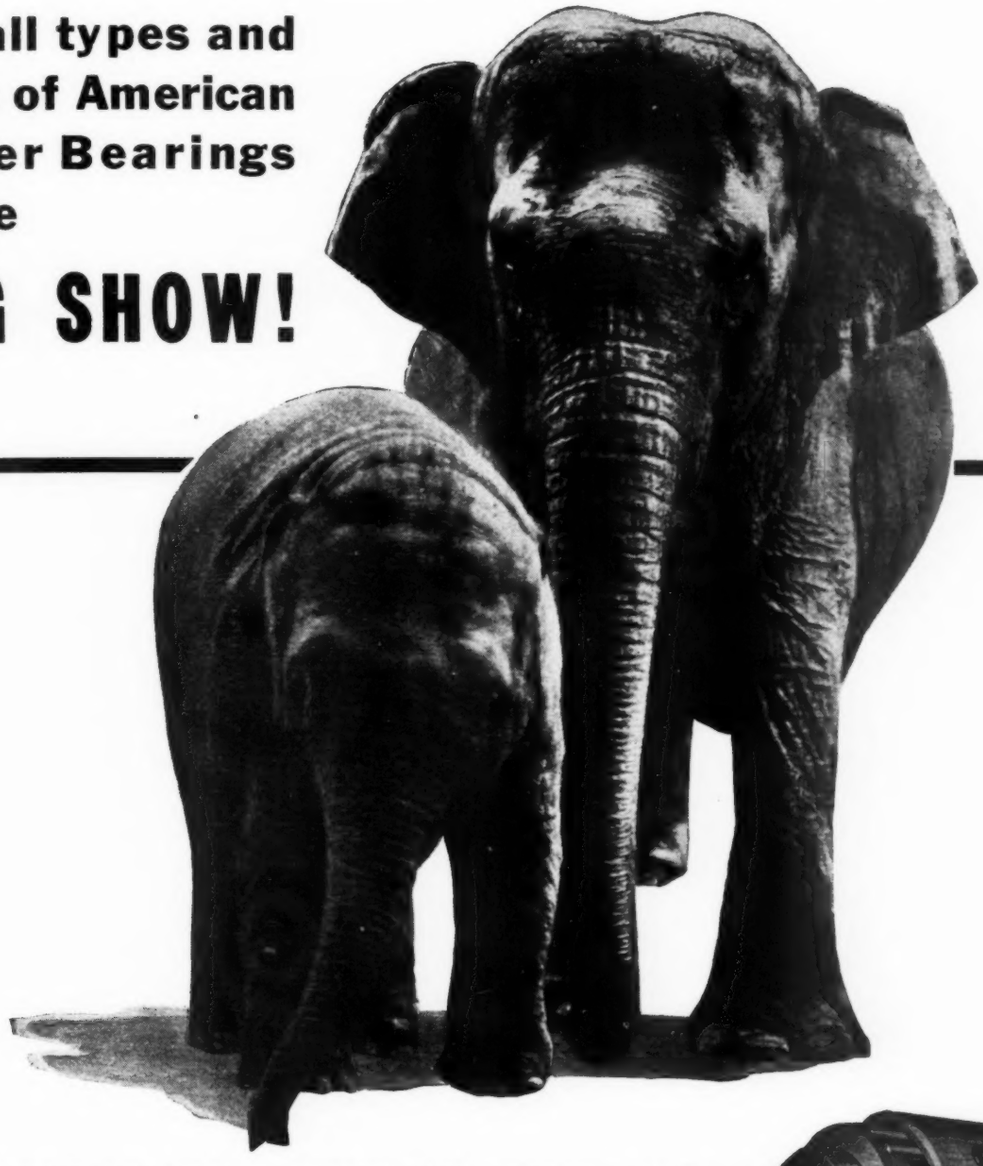

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ing and exploitation work, with a view to the discovery of new areas."

A continuation of Argentoianu's statement points out that the Roumanian government does not have the necessary capital for the work and that foreign capital should be encouraged by assurance of just treatment.

The statement says further:

"It has been decreed to institute two Commissions, made up of geologists, technicians, administrative officials, and leaders of petroleum companies operating today, which are to make proposals which will be concreted in a five-year plan, outlining the country's policy with regard to the exploitation and exploration of its oil resources.

"This plan is to be fixed in such a way that no future Government, nor future Minister, will be able to modify it within this five-year period. To control the application of this plan there would be instituted a 'Superior Council of Petroleum'."

A similar policy would be followed with respect to gas, it was stated.

In the new Roumanian Government, recently appointed, Argentoianu is no longer Minister of Industry and Commerce. He is a member of the Regal Council, however, and his successor, M. Mititza Constantinescu, is said to have adopted the five-year plan.

●

New Order Regulating Panhandle Gas

The Texas Railroad Commission is making a renewed effort to enforce ratable takings of sour natural gas in the West Panhandle field, Texas. Early this month a sour gas proration order was issued, the first since the former one was invalidated in February, 1937, by the United States Supreme Court. In the new order the commission has included rock pressure as a factor in the proration formula. The lack of such a factor caused the voidance of the former order, as the Supreme Court construed it as failure to lessen or prevent drainage.

The formula assigns two-thirds of the per well allowable to the product of acreage times rock pressure and one-third to potential. A maxium of 640 acres is permitted assigned to one well for proration. The invalidated formula assigned one-half the allowable on potential and the other one-half on acreage.

Per well schedules will be compiled soon by engineers in an effort to enforce the ratable taking order.

In the absence of a proration order, the only restriction on production has been a statutory limit of 25 percent of the potential. The field's potential, as stated in the order, was 6,918,229,000 cu. ft. as of July, 1937. There are 391,613 acres in the sour gas area. Virgin pressure was estimated at 430 lb. per sq. in., the weighted average, as determined by the commission's tests, having declined from 359.72 lb. in July, 1935, to 345.28 lb. in July, 1937.

●

Interstate Oil Compact Commission Meets

At a constructive meeting in Wichita, Kansas, and elsewhere the Interstate Oil Compact Commission heard Governor Huxman of Kansas request increased markets for Kansas oil to the extent of 33,000 bbl. per day. Numerous recent discoveries of new fields in that state have increased its potential production far out of proportion to the market allotted.

Dr. Joseph E. Pogue presented data indicating that production and runs to stills should be reduced inasmuch as the increase in demand may be less than expected and crude and motor fuel stocks in storage are already excessive.

Dr. Alexander Sachs proposed a committee on economics to act in an advisory capacity, and Dr. Sachs, Dr. Pogue, and E. de Golyer were appointed to serve on this committee. Two other members are to be appointed later by Colonel E. O. Thompson.

The advisory committee recommended a reduction of crude runs to stills of 15 percent for the next 60 days in order to reduce motor fuel stocks in storage.

It was indicated clearly that although the major companies are willing to coöperate in any project to benefit the oil industry, the attitude of the federal government, as attested by its recent activities, prohibits their entering into any agreements not specifically authorized.

F. B. Plummer discussed water-oil production ratios and suggested further study of ways of reducing costs and increasing ultimate recovery by reducing water-oil ratios.

●

Revised List of Geologic Names

The Shreveport Geologic Society has compiled a tentative revised list of geologic names for the deeper zones in northern Louisiana and southern Arkansas. This list, which is being used by most of the geologists in the area, is as follows:

Trinity group (Comanchean Cretaceous).

Paluxy formation: Non-marine upper Trinity sands grading southward and southwestward into marine. (Oil-producing zones of Caddo district and De Soto-Red River field in upper part of Paluxy).

Glen Rose sub group.

Upper Glen Rose formation: Marine limestones, shales, sandstones, and thin anhydrite stringers.

Glen Rose anhydrite: Massive anhydrite.

Lower Glen Rose.

Rodessa member: Marine limestone, oolites, coquinas, shales, and thin anhydrite stringers. (Oil-producing zones of Rodessa in this member. Also, Jeter zone of Sligo, gas of Logansport field, and Kilpatrick gas zone of Sugar Creek field).

Pine Island member: Black and green shale, some brown shale in lower part. Limestone at base locally. (Dixie and Dillon producing zones of Pine Island in this member; also Pettit zone of Sligo in this member, Oakes zone of Lisbon field, and the Darrett horizon of Sugar Creek occur in this member and its transition zone with the underlying Travis Peak).

Travis Peak formation: Non-marine red shales, siltstones, and mudstones. (Herndon sand of Pine Island, Holloway sand of Cotton Valley in top of Travis Peak, Darrett oil zone of Sugar Creek, Carter sand lens in top of Travis Peak and in basal part of Darrett zone.

Pre-Comanchean (?), Pre-Trinity (?).

Cotton Valley formation: Black marine fossiliferous shale in Louisiana Basin. (Davis and Bodcaw deep sands of Cotton Valley field). Schuler facies of Cotton Valley formation, non-marine red shales, mudstones, siltstones. Typically developed in the Schuler field, Union County, Arkansas. (Morgan sands near top and Jones sand at base in Schuler field).

Buckner formation: Red and green shales, anhydrite (pink), streaks dolomitic limestone. Salt lenses at Rodessa?

Smackover limestone: Buff limestone with Reynolds oolitic member at top. (Gas and distillate at Snow Hill, oil at Buckner, gas and oil at Schuler).

Eagle Mills formation: Red shales and mudstones. Anhydrite and salt in South Arkansas is considered equivalent in age.

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Latest Activities In The Oil Fields

McKNAB and Blair No. 1 Hittle, in S NE 21-31s-4e, in the old Hittle area of Cowley County, Kansas, opened a new producing zone for that field when it filled 1700 ft. with oil after drilling one ft. into the Arbuckle lime at a depth of 3280 to 3281 feet. Wells previously drilled produce from the shallower Stalnaker sand.

•

Republic Production Company No. 1 Lutcher-Moore, in 10-6s-13w, in the Bancroft area of Beauregard Parish, Louisiana, flowed an estimated 3,000,000 cu. ft. of gas per day at a pressure of 2500 pounds. Although operators have not released much information, total depth is reported to be 7950 ft., plugged back to 7600 ft. for completion.

•

Duwe and Farris No. 1 Hadley, in SE NE SE 12-11s-18w, Ellis County, Kansas, filled with oil at the rate of 70 bbl. per hour after the plug was drilled. Potential production is estimated to be 2000 bbl. per day from the Arbuckle lime at a depth of 3329 to 3331 feet. The well is one and three-fourths miles south of the Burnett pool discovery well and is two and one-half miles from the Bemis field.

•

Arkansas Fuel Oil Company No. 1 Pitts, in the Lockhart Survey, Marion County, Texas, flowed 60,000,000 cu. ft. of gas per day from the Hill sand, the top member of the Glen Rose, which produces gas in the Rodessa field but was not productive in wells previously drilled in the Jefferson district. The well was drilled to the Travis Peak section of the lower Trinity and plugged back, and the 7-in. O. D. casing was gun-perforated with 50 shots at a depth of 5930 to 5943 feet. The well is two and one-half miles from the south end of the Jefferson district.

R. J. Wixson No. 1 Peterman, in SWC 28-17s-10w, southwestern Ellsworth County, Kansas, had an initial potential gauge of 785 bbl. per day from Arbuckle lime at a depth of 3298 feet. The well is a mile north of the Stumps pool.

•

Mack Hays and Montour Production Company No. 1 Chittenden Estate, in SW Amerada subdivision No. 18, L. Kratz Survey No. 335, Jones County, Texas, pumped 144 bbl. of 42.3-deg. gravity oil in an eight-hour pumping gauge. Casing was set at a depth of 2093 ft. but not cemented before testing the well. The producing zone is the Swastika, a sandy lime at a depth of 3004 to 3014 ft. and sand from 3014 to 3022 ft., the total depth of the well being 3022 feet. The new field is eight miles northwest of Anson and is the second field in the county to produce from the Swastika.

•

Helmerich and Payne and Continental Oil Company No. 1 Ohio-Sadie O'Dowd, in Section 896, Block D, John H. Gibson Survey, Yoakum County, Texas, flowed two bbl. of oil per hour and 6,000,000 cu. ft. of gas per day while fishing for tools. The producing zone was entered at a depth of 4945 ft. and penetrated to 4955 feet. The well is one and one-half miles southwest of the Denver field, which is now virtually connected with the Wasson pool of northwest Gaines County. One and one-half miles east of this well the Shell Petroleum Corporation No. 1 Dowden flowed 36 bbl. of fluid, half of which was oil, in two hours following treatment with 2000 gal. of acid. Gas accompanying the fluid gauged 126,000 cu. ft. per day. Total depth of this well is 5040 feet.

AVERAGE CRUDE PRICES

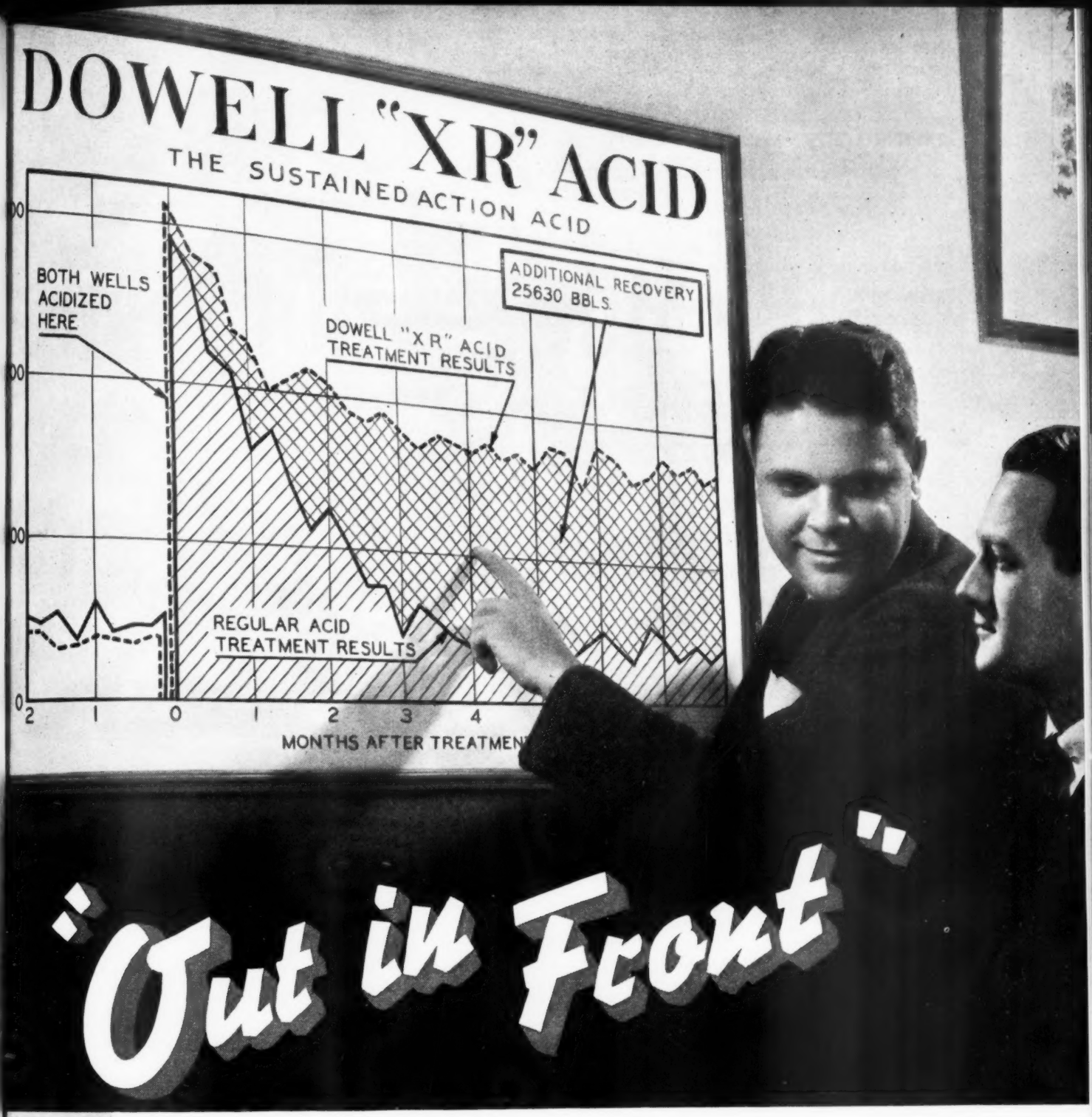
California	
Kettleman Hills	$1.19-1.43
Playa Del Rey	.80-1.16
Coalinga	.70- .90
Signal Hill	.80-1.21
Montana	1.35
Wyoming	.97-1.30
Colorado	1.12-1.18
New Mexico	.78-1.08
Texas	
North Central	.96-1.20
Panhandle	.91-1.08
West Texas	.78-1.08
Gulf Coast	.95-1.41
Darst Creek	1.09
East Texas	1.35
Talco	.73
Kansas	.98-1.30
Oklahoma	.98-1.30
Arkansas	.90
Louisiana	
Rodessa	$ .91-1.25
Gulf Coast	.84-1.41
North Louisiana	.90-1.22
Illinois	1.35
Kentucky	1.40
Indiana	1.12
Ohio	
Lima	1.25
Michigan	1.27
Pennsylvania	
Bradford	2.05
Southwest	1.71
Eureka	1.65
Buckeye	1.55
Corning	1.27
West Virginia	1.67
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in Barrels)

	B. of M. Dept. of Int. Calculations (April)	Week Ended April 30, 1938	Week Ended April 2, 1938	Week Ended May 1, 1937
Oklahoma	526,500	473,900	491,850	665,600
Kansas	173,000	177,750	166,400	198,350
Panhandle Texas	.....	70,700	66,650	78,800
North Texas	.....	77,300	72,600	70,550
West Central Texas	.....	29,650	28,950	32,750
West Texas	.....	197,500	191,950	199,600
East Central Texas	.....	103,250	98,950	118,200
East Texas	.....	433,200	429,700	459,250
Southwest Texas	.....	234,400	229,900	229,350
Coastal Texas	.....	206,700	202,200	199,400
TOTAL TEXAS	1,329,800	1,352,700	1,320,900	1,387,900
North Louisiana	.....	76,700	80,250	73,650
Coastal Louisiana	.....	183,900	182,200	178,350
TOTAL LA.	239,800	260,600	262,450	252,000
Arkansas	40,000	54,550	54,400	27,000
Eastern	132,600	145,700	142,600	120,500
Michigan	51,400	52,100	52,850	46,850
Wyoming	46,600	46,350	48,550	51,600
Montana	12,700	13,850	13,500	16,850
Colorado	4,600	3,650	4,300	4,650
New Mexico	106,000	106,000	104,950	105,950
TOTAL EAST OF CALIF.	2,663,000	2,687,150	2,662,750	2,877,250
California	698,700	709,000	704,500	620,200
TOTAL U. S.	3,361,700	3,396,150	3,367,250	3,497,450


DOWELL "XR" ACID
THE SUSTAINED ACTION ACID
BOTH WELLS ACIDIZED HERE
ADDITIONAL RECOVERY 25630 BBLS.
DOWELL "XR" ACID TREATMENT RESULTS
REGULAR ACID TREATMENT RESULTS
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MONTHS AFTER TREATMEN

"Out in Front"

OUT IN FRONT . . . with New Developments

Dowell's latest achievement is "XR"—the Sustained Action Acid.

This new type acid contains an ingredient that sustains the dissolving action until the acid has penetrated to the most distant area of the pay. And, it's *Inhibited*, of course—preventing costly damage to tubing and casing.

Moreover, Dowell "XR" Acid is introduced into the formation at the regular rate—no loss in strength is suffered due to increased velocity as with multiple pump treatments. It arrives at its destination fresh and vital.

With "XR" Sustained Action Acid, Dowell can develop increased production for thousands of operators—and, as the chart shows, this production gain lasts longer.

Since the beginning, Dowell has stayed "out in front" with new developments in acidizing. It has brought to the industry every major contribution to the art. You can stay "out in front" with Dowell.

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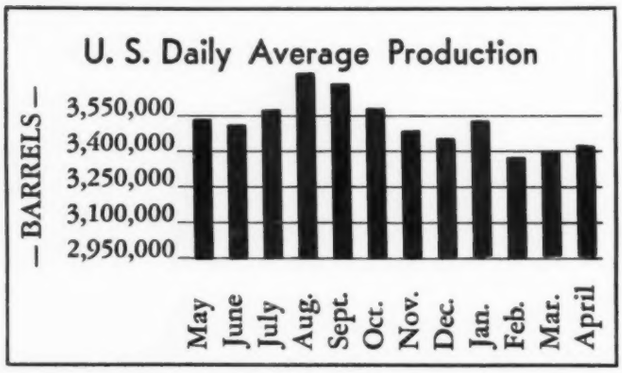
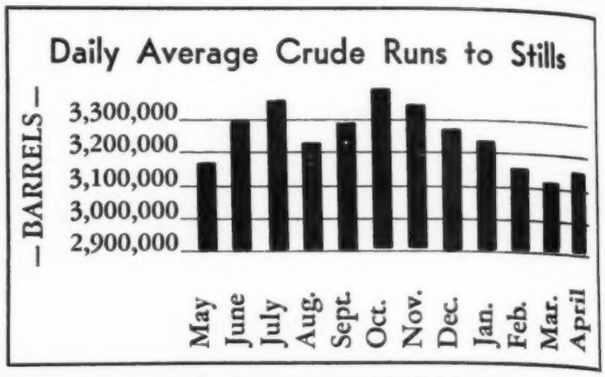
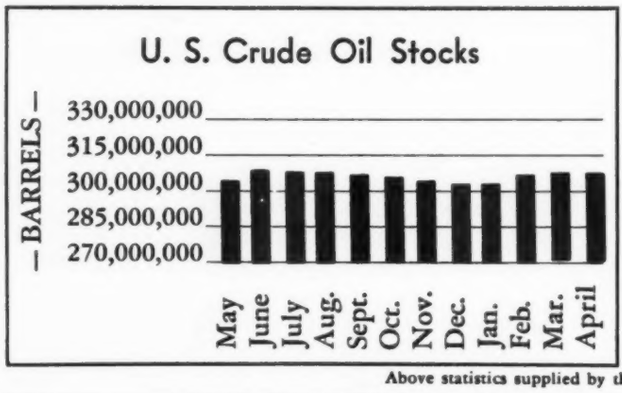
General Office: KENNEDY BUILDING, TULSA, OKLA.

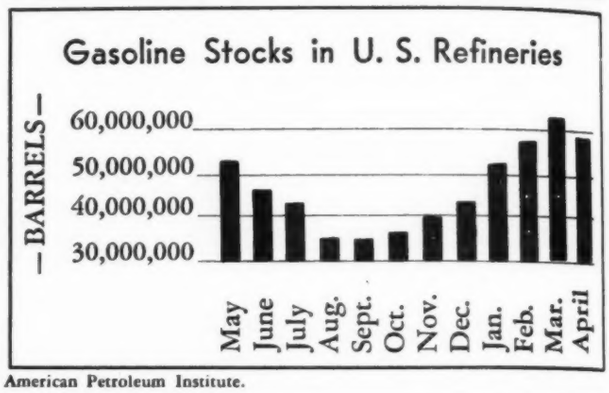
IL AND GAS WELL CHEMICAL SERVICE

Summary of Petroleum Statistics and Field Activities









Above statistics supplied by the American Petroleum Institute.

Summarized Operations in Active Fields for April, 1938

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	202	196	37	110	3500-3700	2	40	Rotary
Duval County	51	36	7	26	1554-2900	2	22	Rotary
Ector County	50	50	21	110	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	29	28	45	148	1700-3900	2	40	Rotary
Refugio County	15	14	2	8	4900-5900	2	38	Rotary
Nueces County	36	29	12	38	3922-5878	2 or 3	21-54	Rotary
Winkler County	18	18	7	20	2850-3450	2 and 3	30-38	Rot.-Cab.
Talco Field	7	5	1	4	4230-4361	2	16-24	Rotary
K. M. A. Field	84	82	45	180	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Oklahoma City	11	10	2	15	6450-6682	3	39	Rotary
Fitts Pool	17	14	3	9	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	20	15	7	42	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	11	10	4	16	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	23	20	4	20	3290-3518	2	39-42	Rot.-Cab.
LOUISIANA-TEXAS-ARKANSAS								
Rodessa	21	21	7	28	5950-6450	3	39	Rotary
ILLINOIS								
Central Illinois	101	79	32	131	2950-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	46	41	12	96	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	2	1	1	17	8300-8730	3 or 4	40	Rotary
Wilmington	30	30	22	45	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for April, 1938

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1937 (In Barrels)
	April	March	April	March	April	March	April	March	April	March	
Arkansas	23	16	19	14	24	20	20	21	35	34	12,088,341
California	112	84	93	80	109	132	87	116	235	247	238,587,663
Colorado	1	1	1	1	....	....	2	3	27	24	1,532,893
Illinois	75	71	57	46	....	....	129	131	41	39	7,376,022
Indiana	5	17	2	10	....	....	5	3	26	28	820,000
Kansas	137	141	101	101	159	126	42	47	249	281	70,542,000
Kentucky	48	57	31	41	....	....	10	8	71	75	5,500,000
Louisiana	71	81	51	64	107	94	52	51	183	180	90,501,068
Michigan	31	63	18	39	65	81	29	25	131	130	16,254,181
Mississippi	1	2	0	2	....	....	4	4	7	6	Gas Prod.
Montana	3	6	3	4	....	....	3	2	50	49	5,775,000
New Mexico	52	45	46	39	....	....	10	11	170	171	38,642,184
New York	....	....	....	....	....	....	....	....	....	....	5,466,200
Ohio	65	79	54	61	....	....	49	54	141	147	3,547,600
Oklahoma	173	170	129	118	205	167	50	46	325	318	225,402,731
Pennsylvania	....	....	....	....	....	....	....	....	....	....	19,154,400
Texas	1093	1109	857	873	1379	1407	429	369	1397	1271	506,891,233
West Virginia	45	65	27	56	....	....	24	25	111	120	3,833,000
Wyoming	7	10	6	9	....	....	9	8	70	68	19,402,121
Total	1942	2017	1495	1558	2048	2027	954	924	3269	3188	1,271,316,637

Recognition

Wherever Jell Mud is Used

The superiority of JELOX over ordinary powdered bentonite is recognized wherever jell mud is used. The ready acceptance of JELOX by leading operators more than justifies any claim ever made for it. Definitely JELOX is the successor to bentonite.

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SHELL BUILDING
HOUSTON, TEXAS

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Progress of Major Pipe Line Work

A NEW dehydration plant has been placed in operation on the Denver line of the Canadian River Gas Company. The plant is 22 miles northwest of the company's Bivins compressor station and has a capacity of 90,000,000 cu. ft. of gas per day. The company also has added a 600-hp. Clark Brothers compressor to the equipment in its Bivins station. This unit will be operated during peak loads and as a standby.

●

Although no definite announcement has been made, it is believed a major company soon will lay a pipe line to the Schuler field, Union County, Arkansas. Lion Oil Refining Company on May 1st ceased taking oil from the field except from its own wells and those in which it has an interest, leaving the Root Petroleum Company the only purchaser. As Schuler is the most active field in Arkansas it is thought there will be no great delay in some company providing it with another pipe-line outlet.

●

The Manufacturers Light and Heat Company of Pittsburgh, Pennsylvania, affiliate of the Columbia Gas and Electric Corporation, is seeking permission from the Pennsylvania Public Utility Commission to lay a 3½-mile natural gas pipe line to the Lukens Steel Company plant at Coatesville, in the coal mining area of Pennsylvania. The outcome of this petition is being watched with interest by gas interests in the East because last year the Columbia Gas and Electric Company sought to extend its gas service into the coal belt and was prevented from doing so by the commission upon instruction from Governor Earle. The latest petition, it is said, also is being opposed by coal and railroad interests.

Some difference exists between the petition of last year and the more recent one that is seen as a possible loop-hole for the latter to be granted. The petition of last year proposed service for several communities in the coal area, whereas the petition of the Manufacturers Light and Heat Company is for service to only one large industrial user. Steel company officials state that unless they obtain natural gas, which they say will save them $250,000 annually, they will be forced to close their plant. The population of Coatesville is dependent almost entirely upon the steel company for employment.

●

The construction of an 8-in. gas pipe line from the Cotton Valley field, Webster Parish, Louisiana, by way of the Schuler field, Union County, Arkansas, to El Dorado, Arkansas, is being considered by the Texas Canadian Oil Company. A preliminary survey is being made by Ford, Bacon and Davis, engineering firm of New York City. Whether or not the project materializes will depend upon the success the company has in obtaining a substantial market for the gas in the El Dorado area.

●

The Central Gas Utilities Company, Syracuse, Kansas, is extending its gas line to the D. A. Milsap farm south of Syracuse for the purpose of supplying fuel to engines used in the irrigation of farm lands. It is reported that several other farmers in the area are planning to adapt their water-pumping equipment to the use of natural gas in which event additional pipe lines will need to be laid. The company also plans to extend its line from Holly to Coolidge.

●

The Humble Oil and Refining Company recently laid 4500 ft. of 8-in. pipe from Mesquite Point, western Chambers County, Texas, to the company's first test in the Cedar Point submerged oil prospect. This test, No. 1 State, is an offset to the discovery well, No. 1 State of the Salt Dome-Standard Oil Company. It was necessary to use barges in laying the line in the 6-ft. water.

●

A natural gas pipe line may be laid from the Lloydminster field, Saskatchewan, Canada, to various points in the province. Walter F. Thorn of Moose Jaw recently made an inspection of the field to determine the advisibility of the project, which would be backed, it is said, by interests of Eastern Canada and the United States.

●

City officials of Little Rock, Arkansas, are considering a proposal, which, if accepted, would involve the construction of a 120-mile, 13-in. gas line from the Clarksville field. J. E. Josey of Houston, Texas, has offered to supply natural gas at the city gate for 15 cents a thousand cu. feet. If city officials accept this proposal steps will be taken to purchase the distribution system of the Arkansas-Louisiana Gas Company, which is now serving Little Rock with gas from Louisiana fields.

●

The Standard Oil Company of Ohio has abandoned, temporarily at least, its proposed plan to construct a pipe line from the Ogemaw-Arenac oil fields to a floating terminal on Lake Huron off Whitestone Point, a distance of 25 miles. The action was caused by protests of resort property owners and interests who claimed the project would be a menace to the Saginaw Valley fresh water supply. If the pipe line is laid eventually, officials state, it likely will be to Bay City, Michigan. Facilities for lake tanker loading already are available at that point.

●

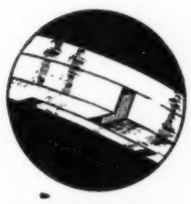
The Washtenaw Gas Company's petition for permission to supply Ann Arbor, Michigan, with natural gas from Texas will be given a re-hearing by the Michigan Public Utilities Commission. The project would involve the laying of a lateral from a trunk line running to Detroit. The petition was denied in March on the grounds that sufficient gas was available in Michigan without bringing it in from elsewhere. It was contended that the Michigan gas would be cheaper, because of the saving in transportation cost, and that the development of Michigan's natural gas resources would help bring prosperity to the state.

No exceptions!

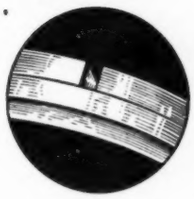
only COOKTITES *have maximum*

DEPENDABILITY

Brief and to-the-point are these few words of a typical COOKTITE user. He knows from results that COOKTITES have no focal weakness—that they ride over cylinder variations without straining the joint seal, whether these variations result from localized wear or unequal expansion—and that, having also full depth radial strength, truly COOKTITES alone have maximum dependability.



The Groove Seal — The illustration shows the upper ring acts as a supporting bridge for the free ends of the lower ring. This substantial construction prevents development of stresses of a cantilever nature which so frequently cause failure in designs that depend on self-engaging ring ends for both groove and cylinder seal.



The Cylinder Seal — As you would expect, the free ends of the upper ring are independent of one another, yet restrained on the lower ring member. Note the uniform single-ring bearing on the groove landings, yet the cylinder has dual ring contact for more effective seal.

Full Depth Radial Strength — This exclusive COOKTITE feature imparts the dependability of a plain ring. The illustration also shows the flange extension that completes the groove seal. Note that the flange proper prevents the lower ring from straining the sealing extension.

Operators of Gas and Diesel Engines looking for a ring that has maximum dependability—gives maximum power and proved satisfaction should insist on COOKTITE SEALING RINGS. Complete information on the full line of COOK'S GRAPHITIC IRON Piston Rings will be sent gladly on request.

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The Month's Activities in Refining

Percent Refining Capacity Operated

Western Division, 75.2 Percent **Central Division, 79.0 Percent** **Eastern Division, 80.9 Percent**

WORK has begun on the Inland Empire Refineries' plant at Spokane, Washington, it has been announced by Emby Kaye, general manager, who will be in charge of operations of both the Spokane and Pocatello, Idaho, refineries being constructed by the company. The plant at Spokane is being erected north of the Hillyard area and will cover approximately 50 acres of grounds. The company has leased a 120-acre tract for the refinery and grounds. The refinery will have a capacity of about 2000 bbl. per day.

●

The refinery being constructed at Bari, Italy, by the Azienda Nazionale Idrogenazione Combustibili, begun a year ago, is now employing several hundred men and construction work is progressing rapidly, although the expected date of completion has not been announced. Electric power needed by the refinery will be supplied by a generating station now being constructed in close proximity to the plant by the Societa Meridionale di Elettricita. The refinery will obtain its crude oil supplies from the Albanian oilfields of Devoli. They will be brought to the S. Cataldo pier of Bari by tanker and boosted the rest of the way to the refinery by pipe line. Water required for processing will be taken from the sea.

The A.N.I.C. has another large refinery in an advanced stage of construction at Leghorn.

●

The Maritime Oil Company, Houston, Texas, has begun construction of a 5000-bbl. refinery on the Houston Ship Channel. The plant will specialize in the manufacture of Diesel fuel and other special fuel oils and in aviation and other high-octane gasolines. The Mid-Continent Engineering Company of Dallas is supplying the plans and superintending the construction of the plant.

●

National Refineries, Inc., has been incorporated at Calgary, Alberta, Canada, by interests associated with the National Petroleum Corporation. The latter has one producing well in the Turner Valley field and another is nearing completion. The newly-incorporated company will erect a refinery to process the crude, it is stated.

The Del Rey Producing Company of Houston, Texas, has started construction of a natural gasoline plant in the Sandy Point field, Brazoria County, Texas. The capacity of the plant will be 20,000,000 cu. ft. of gas per day.

●

The Shamrock Oil and Gas Company may erect a natural gas recycling plant in Hidalgo County, Texas. Tests are being made to determine if this is advisable. A survey has been made of the La Blanca field and tests are to be made of other fields in the Lower Rio Grande Valley.

●

The Dale Oil and Refining Company has completed the construction of its refinery at Dale, Texas, and is now processing crude oil from the Buchanan field and the northern Caldwell area. High-octane gasoline, kerosene, furnace oils, and bunker fuel oils are being manufactured. R. Ranne, San Antonio, is president of the company; Fred Tolleson is sales manager; and R. E. Goode is in charge of refining.

●

The Globe Oil and Refining Company is remodeling its refinery at Lemont, Illinois, with a view to obtaining a greater recovery of heating oils. Additional tankage also is being provided. The refinery has a crude capacity of 16,500 bbl. per day and a cracking capacity of 8000 barrels.

●

Pure Oil Company has resumed operation of its refinery at Muskogee, Oklahoma, on a limited scale. The plant has been shut down for several months while new equipment was being installed.

●

The Louisiana Iron and Supply Company, which acquired the Trinity Refinery at Gladewater, Texas, following receivership, will re-open the plant as soon as the equipment has been reconditioned. The plant has been idle for several months. The refinery has a capacity of 3000 bbl. of crude per day.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ended April 30, 1938

A.P.I. Figures

(Figures in Barrels of 42 Gal. Each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	493,000	73.7	22,757	9,902
Appalachian	88.4	108,000	83.7	3,465	1,365
Ind., Ill., Ky.	92.4	417,000	85.3	15,017	7,736
Okla., Kans., Mo.	84.7	262,000	68.4	8,134	3,664
Inland Texas	56.6	135,000	67.2	2,628	1,625
Texas Gulf	95.7	787,000	98.7	13,627	8,723
La. Gulf	96.6	132,000	78.6	2,275	2,987
No. La.-Ark.	63.7	42,000	72.4	529	609
Rocky Mt.	69.7	51,000	82.3	2,275	796
California	90.9	509,000	68.2	15,672	88,263
Reported	89.0	2,936,000	79.3	86,379	125,670
Est'd Unreported		279,000		4,960	2,600
*EST'D TOTAL U.S. Apr. 30, '38		3,215,000		91,339	128,270
*EST'D TOTAL U.S. Apr. 23, '38		3,150,000		91,479	127,148
U.S. B. of M. *Apr. 30, 1937		**3,119,000		80,667	94,207

*Estimated Bureau of Mines' basis.
**April, 1937, daily average.

THE Petroleum Engineer

MAY, 1938

The Economic Rehabilitation of Stripper Wells

Details of one company's two-year program reveal some useful facts to those faced with the problem of rehabilitating or abandoning their stripper properties

By THOMAS HOWARD RODGERS

ALTOGETHER too few of us recognize a noticeable shortcoming of petroleum engineering. The writer was present at a recent discussion that took place between two petroleum engineers representing two California companies. One had been volunteering information about the trials, successes, and failures he had had in using the gravel-pack method of completing new wells, and in the acid-treatment of old producers.

In his affable manner he made a remark that illustrates this one failure of petroleum engineering. He said, "You know these geologists are very wise fellows. As often as possible they gather together for geological discussion, or Jim will drop in on Bill for help on some phase of interpretation, and they all profit from it. But we fool engineers sit alone, each in his own office, worrying along without help, and nobody profits. Each man makes mistakes or overlooks opportunities that an intercourse of ideas would prevent. If I have an idea that works, I like to pass it along."

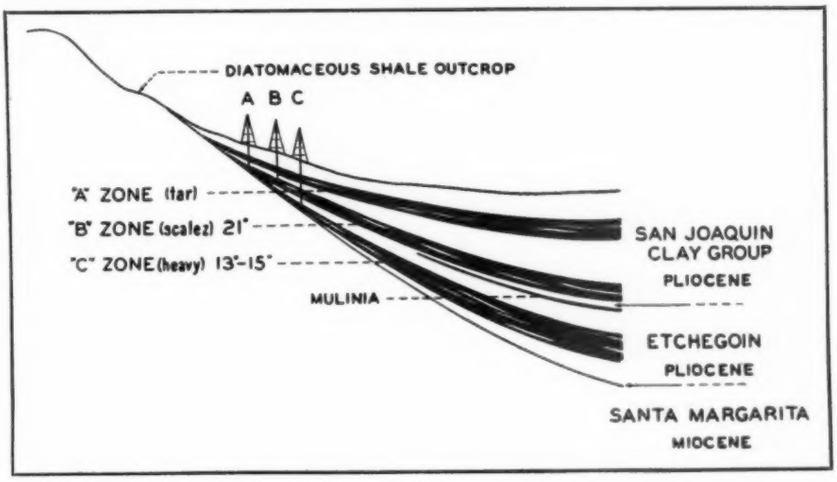


Fig. 1. Schematic north-south cross-section through Midway-Sunset field, California, showing formations encountered in monoclinal production. Notice that well "A", of which there are a number of examples, is situated upstructure and produces from both zones with a mixed gravity of 17. Downstructure, the gravity as in well "B" is 21.0, and in well "C", 13 to 15.

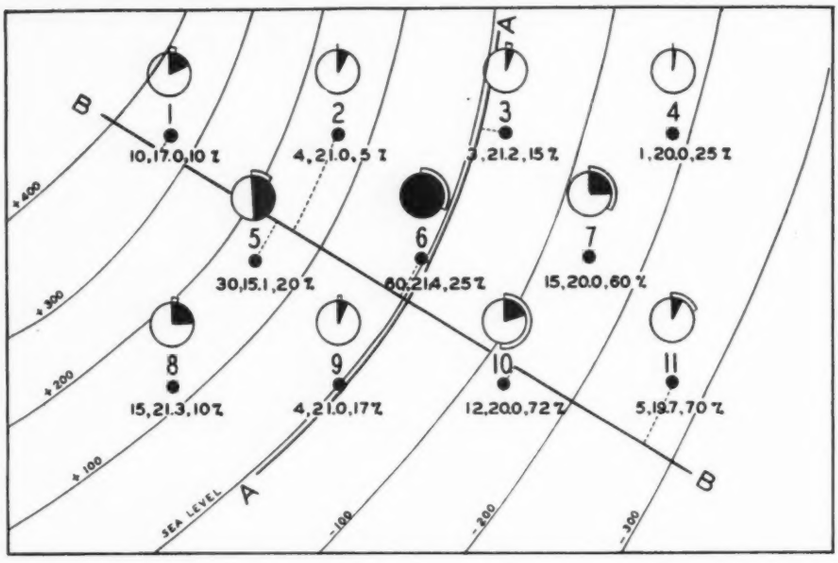


Fig. 2. A small example area showing production plotting, contouring of the top of an oil sand, dip and strike cross-sections. Production figures for each well read: average daily net bbl. of oil, gravity, percent of water. Well 6, successfully deepened, is the key well.

Now, while no particular claim of originality appertains to this article, we feel that the manifold production plotting, cross-sectioning, correlating, interpreting, engineering, and beads of perspiration involved in a two-year program of the work to be described, have given us some sifted principles and results that might prove useful to companies operating under conditions similar to those found in the Midway-Sunset field of California, and more particularly to sections 36, T-31-S, R-22-E; 31, T-31-S, R-23-E; 6, T-32-S, R-23-E; and 1, T-32-S, R-22-E, M. D. B. & M. It may be that the entire program will be useful to that ever-growing list of companies who, like ourselves, are faced with the maintenance of old properties that present the urgent problem of either the economic rehabilitation of stripper wells, or their abandonment.

The most common methods of stimulating production in an old field are well known. We think first of the widespread use of vacuum pumping. Then there is the principle of gas or air injection. In one instance, in the field under discussion, water-flooding proved beneficial. Lately attention has turned to chemical treatment—acid in the case of limestone formations, and an effervescent, exothermic reaction of sodium hydroxide and aluminum in the case of asphalted or mudded wells, or those completed in other than limestone deposits. For our purposes, gas injection and chemical treatment were tried with questionable success, while so drastic a measure as water-flooding was postponed as a last and most desperate effort to save a dying field.

Our rejuvenation of old wells took the form of cable-tool redrilling and deepening. That it met with financial success—that it more than satisfied that ultimate criterion—can be verified by a glance at Table 1. This is a typical field balance sheet for this kind of work, and covers 27 months of activity in the Midway-Sunset field. It is compiled in the field office and serves as a constant guide to the merit of the work, both collectively as a program, and individually by wells. The statement is self-explanatory with perhaps the exception of the column headed "less net revenue if undeepened." This deduction from gross revenue is set up to take into account wells worked on that were making a small net profit before being deepened. It seems fair thus to penalize subsequent profit or loss to the extent of what the well would have made had it been allowed to continue its stripper existence, even though one might argue that the risk involved in deepening should wipe the slate clean. Particularly gratifying is this type of financial analysis to the manager who is wearied of diffuse costs, uncertain operations, obscure profits, and who can thus have before him a complete and contemporary picture of the status of individual wells.

From the outset we found little in the way of precedent or current writing covering the work we proposed to do. It seemed that in this heyday of developmental competition, attention had been focused largely on new fields and their problems, whereas the depleted areas went without remedial attention. So we shall now consider in detail the steps an operator must take in the cable-tool reconstruction of old properties. We shall look at the geological detail, the production plotting, the contour drawing, the dip and strike cross-sections, the correlations, and the engineering detail that will occupy the operator's mind.

First of all the groundwork must be

TABLE I

Profit and Loss Summary of Deepening Work Through First 27 Months

Well	Date completed	Gross revenue	Less net revenue if undeepened	Calculable gross revenue	Total cost deepening and upkeep	Profit or loss	Months on production	Return on investment percent	Avg. daily bbl. oil present	Before deepening: Avg. daily bbl. oil	Before deepening: Cost per bbl.
11-21	June, 1935	$ 8,296.48	$—1,984.60	$ 6,311.88	$ 5,142.44	$ 1,169.44	27	123	13	5	$ .12
12-21	Sept., 1935	3,775.92		3,775.92	5,872.80	— 2,096.88	24	64	5	2	.87
4-21	Nov., 1935	5,950.50		5,950.50	11,303.79	— 5,353.29	22	53	25	5	.18
16-36	Dec., 1935	79,871.40		79,871.40	3,493.45	76,377.95	21	2286	145	22	.10
22-36	Jan., 1936	15,133.80	—883.30	14,250.50	6,077.39	8,173.11	20	234	39	10	.54
11- 1	Mar., 1936	.....	.....	.....	2,000.85	— 2,000.85	Suspended	....	....	5	.20
22- 6	Mar., 1936	11,893.00		11,893.00	6,046.46	5,846.54	18	197	47	Dry	
14-36	May, 1936	70,804.95		70,804.95	6,853.40	63,951.55	16	1033	190	Dry	
2- 1	June, 1936	16,788.10		16,788.10	7,480.84	9,307.26	15	224	40	1	4.51
23- 1	July, 1936	17,560.90	—1,587.46	15,973.44	7,806.71	8,166.73	14	205	53	7	.12
1- 1	Aug., 1936	15,951.36		15,951.36	6,526.75	9,424.61	13	244	53	2	1.41
9-36	Oct., 1936	22,523.76		22,523.76	8,520.59	14,003.17	11	264	80	3	3.20
23-36	Dec., 1936	34,302.06	—2,282.02	32,020.04	4,582.58	27,437.46	9	699	177	13	.11
8-36	Uncompleted				21,848.43	—21,848.43	....	....	....	1	.31
6A-6	Feb., 1937	3,959.20		3,959.20	11,880.07	— 7,920.87	6	33	31	Abandoned	
13- 6	April, 1937	935.98	—969.60	—33.62	6,621.23	— 6,654.85	6	....	10	12	.07
24-36	Uncompleted				6,896.37	— 6,896.37	....	....	....	16	.10
27-31	Aug., 1937	25.76	—21.76	4.00	9,801.74	— 9,797.74	(4 days)	0.4	7	8	.24
Totals		$307,773.17	$—7,728.74	$300,044.43	$138,755.89	$161,288.54		216			

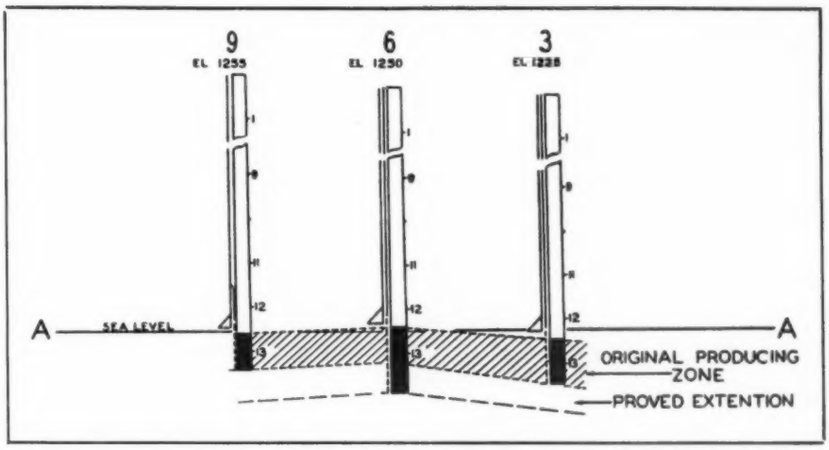


Fig. 3. A contour or strike cross-section. When deepening well 6 proved a 70-ft. extension to the oil zone, correlations to wells 9 and 3 indicated the possibility of two more successful cable-tool extensions.

laid in geological study. The more exhaustive the reconnaissance the more certain the results. At every turn the geological import of an engineering decision must be known. Certainty and confidence result when structural facts are constantly at one's fingertips. Fig. 1 shows the general geology of the Midway-Sunset field, California, as found in a dip section beginning in Sections 1, T-32-S, R-22-E, and 36, T-31-S, R-22-E, and continuing toward Buena Vista hills to the northeast. Producing wells in this area are located on a monocline, in which the oil sands of Pliocene age pinch out against the underlying Miocene formations that rise to an anticline in the hills to the south.

In the years following 1910, cable tools were used in an attempt to develop one of two sands, either the "B" zone, which is at the base of the San Joaquin clay group, is some 100 to 150 ft. thick and carries 21.0-gravity oil, or the deeper "C" zone, which is near the base of the Etchegoin of Pliocene age and carries 13- to 15-gravity oil. Between the "B" and "C" zones is a siltstone body averaging 50 ft. in thickness. The "C" zone itself then extends some 40 to 60 ft. deeper. Below the "C" zone is found a color and lithological change from the characteristic blue of the Etchegoin siltstones to the brown silty shales of Miocene age. All the Pliocene beds show down-structure thickening.

These two oil sands have been long-lived. They are fine-grained and rather well-sorted; and they are lenticular, a fact that both hindered and helped in our work. It was an obstacle in that it made exact correlations from well to well difficult in many instances; it was beneficial in that it made possible the extension of producing intervals to revive wells. For at the outset an important question had arisen in our minds. We suspected, as a result of preliminary cross-sectioning, that many of the depleted wells had not originally completely penetrated the "B" or "C" zones. Cable-tool methods in the early life of the field, when as many as 30 strings of tools were running, were such that no particular attention was paid to this aspect of development. In fact we were assured by some of the "old timers" that when the tools had penetrated the top of the oil sand, were then blown out of the hole by the initial pressure and scattered around the countryside, the operators felt themselves lucky to complete the well at whatever the penetrated depth might have been. So then our question became: Will the deepening of a well to uncover new sand in the same strata revive production, or will there have been an upward drainage through the years that served to dry up the sand below the shoe of the oil string? When we deepened well 16, Section 36, 31-22, the results were far better than our expectations. Here was a well originally completed in January, 1911, at a depth of 990 feet. To the close of the year 1935, during a productive life of 24 years, the well had produced 1,166,334 bbl. of oil, by which time the producing interval was depleted. Cable-tool deepening was completed in December, 1935, and the total depth was now 1095 feet. An additional 105-ft. thickness of formation had been uncovered and bailed-in. Then during the following 90 days, this stripper well averaged 199 bbl. net of 22-gravity oil per day, and the enormous subsequent return on the investment can be seen in Table 1. Our question was answered, and the campaign was on.

From the success of this well we then resolved to search for wells in the vicinity that had possibilities for the tapping of this extended area. The risk was not great as many of the wells were depleted, and even though an extension in the "B" zone should prove a failure the well could be drilled to the heavy gravity "C" zone.

Following geological reconnaissance, we think of the next step as production plotting. In any given field wells seem to fall into natural groups on the map, which may be preserved and the groups studied as units. In our case, no map group of wells more than 2½ miles in diameter was taken, as at a plotting scale of 200 ft. to the inch this was the longest cross-section we could handle in our blue-printing machine. Using this scale, the location map is drawn. Fig. 2 shows an example of production plotting. Beneath each well is shown its present daily net production in barrels, the gravity, and the cut. These figures are then symbolized, as in the illustration, by segments in a circle drawn above each well. The degrees of arc composing this segment necessary to represent one bbl. is an arbitrary figure. We choose a number that will allow the largest producing well to be shown within the circle. Thus if hypothetical well 6, Fig. 2, produces 60 bbl. net per day, six degrees of arc would equal one bbl. and allow the production of all the other wells to be shown proportionately. If the individual production within a unit fluctuates wildly it may be necessary in some cases to use concentric circles, but the degrees of arc per bbl. should not be less than five. It is better to have it ten or even more. If it becomes too small it defeats the purpose of production plotting, which is to aid the eye in visualizing and evaluating the unit studied. When the segments of the circles are colored, the local areas of greatest production immediately stand out and cause one to ask himself if it is not because those wells are penetrating the sand more deeply than their neighbors whose status might be improved. That such a symbolized representation is invaluable in this preliminary evaluation only one who has tried to cope with and assimilate a mass of production figures, cuts, and gravities can appreciate.

In Fig. 2, the water produced by each well is shown in the narrow circle outside the oil circle. This again is a visual aid in studying areas where water troubles are greatest. The same degrees of arc per bbl. is used for water as for oil in order that their relationship may be preserved. It is arrived at easily by the following method, using well 6: As the cut is 25 percent, 60 bbl. net of oil must be 75 percent of the gross fluid, which then is 80 bbl.; 80-60 equals 20 bbl. of water per day,

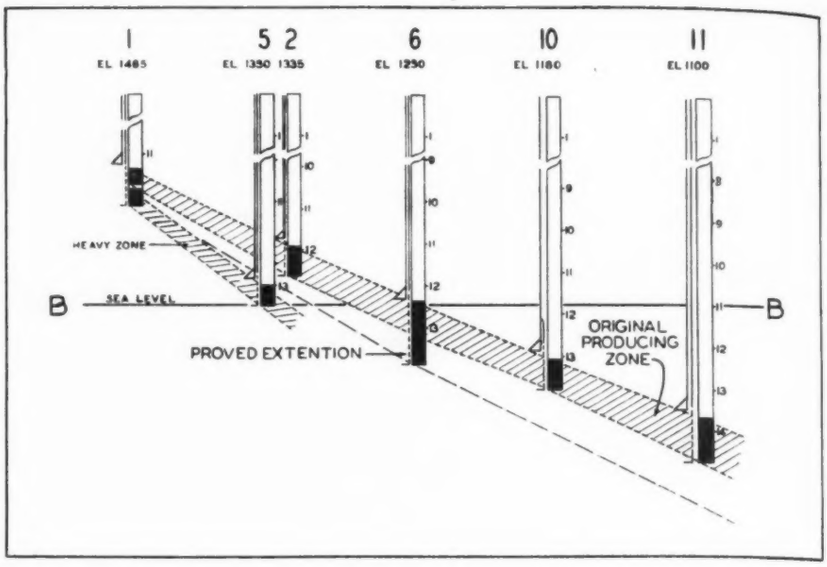


Fig. 4. Typical dip section as found in the Midway-Sunset field. Here again, the extension of well 6 shows excellent likelihood of more zonal thickness in wells 2, 10, and 11. From the production map, Fig. 2, the low gravity of the oil produced in well 5 shows its different zonal origin, while the mixed gravity in well 1 signifies an upstructure well producing from both zones.

which at six degrees of arc per bbl. will be shown by 120 degrees in the water circle.

Drawing of the production map is best done on tracing cloth in ink from which an excellent negative on brown-print negative paper may be obtained using an ordinary sun-printing machine. Instead of blue prints, we favor the silver sensitized brown-print papers even though higher in price. Detail is much clearer, and from one negative any number of positive black-line prints may be made and as many work sheets as needed provided. In addition, the use of the thin pre-transparentized grade of paper makes possible the superimposition of one print upon another, where for example one worksheet contains production plotting, another subsurface contour lines, and still another cross-section lines. By placing one upon another, the production data and contour lines, or the contour lines and cross-section lines, may be related in one glance without unnecessarily cluttering up any single worksheet.

Next, the top of the producing sand underlying the unit area is contoured on a separate print. If this work has been done in some independent geological report to be found at the Bureau of Mines or the U. S. Geological Survey, the contouring is a matter of tracing. If not, the top of the production interval must be shown in elevation above or below sea level for each well, and contour lines interpolated from that basis. Fig. 2 shows the contouring. The illustrations accompanying this article do not attempt to represent any particular group of wells in the Midway-Sunset field. Rather are they drawn schematically in order that conditions encountered may be shown generally, and that all the methods described in this article may be illustrated in a small space. They were all prepared according to the printing method described.

After contouring the unit area will come cross-sectioning for correlation purposes. This may be done by way of dip sections, or strike or contour sections. Some of our geological friends severely criticized the use of any dip section in which, as shown in Fig. 2, wells like No. 2 are brought in and located on the cross-section line from some distance away. This, they declared, was an assumption of strike in Etchegoin sands that, because of the existing lenticularities, would prove disastrous for correlative purposes. We had no right to assume such strike.

Fortunately there was no way to avoid that assumption in attempts to correlate from good wells to prospective wells. Fortunate, indeed, because the balance sheet in Table 1 shows that quite the contrary was true; that results were better when working from well to well along the contour than when using strictly dip correlations. This was due no doubt to the geological conditions of shore line deposits. At any rate pragmatic results must take precedence over geological theory in this business man's world; where the two conflict it is the theory that must conform.

Cross-section "A-A", and Fig. 3, show a typical contour section, with wells brought in and located at right angles to the line. This is in contrast to the dip section "B-B", and Fig. 4, where the wells are brought in to the line not at right angles, but on a strike line parallel to the nearest contour line. The reason is that, where the contoured structure assumes a fan shape, an "S" shape, or even waves slightly, the wells will be found on the dip section in their proper structural elevation with reference to the datum plane. The technique of both types of cross-sectioning is to base everything upon sea level. Transparent graphic well log strips are laid out on thin, transparent tracing paper and on a straight sea level line, properly spaced, and tacked in position with small pieces of transparent tape. This master sheet is then ready for printing, and from it a negative is prepared. The assembled original is laid in the printing frame face down on the silver-sensitized surface of the negative paper, so that ink may contact silver and thus prevent the diffusion of light that would occur through just the thickness of the tracing paper if placed right side up. The negative will then read backwards.

It is difficult to say just how long the paper should be exposed to the sunlight. The intensity of the sun's rays varies widely with the time of year, time of day, and atmospheric conditions. An operator eventually learns that he can depend upon no arbitrary time of exposure. Rather he relies upon the change in color taking place on the uncovered portions of the negative paper to know when the negative is cooked. A light chocolate brown might well describe it. Too much exposure will burn out the white lines of the negative, that is, will reduce the silver that should remain soluble and ionized. Too little exposure will make a negative that will pass light through the general background and spoil any print.

After the negative has been washed, fixed, and dried, imperfections may be blotted out with India ink or a manufactured opaquing fluid. Then using the same process, and placing sensitized surface to sensitized surface, black line prints are made from the negative.

On these prints correlations are made. Zones are sketched in with colored pencil, production data can be posted to each well, casing programs worked out, water troubles plotted and correlated to adjacent wells, and, particularly, progress of deepening work plotted each day as core descriptions are obtained. In this way engineering and geology are coincidental; facts are

before the engineer at all times and are in a graphic form that can be visualized and assimilated quickly. Rare indeed is the man who can envisage structural relationships from a set of figures; still rarer is the man who can produce results from such a visualization.

As correlations are most easily made on a basis of zonal thickness, as shown in Fig. 3, it follows both from the eye and from practical experience that this can be done more accurately under the strike conditions of a contour section than when working with a probable increase in thickness down a monoclinal dip. In some instances, however, we have combined the two by using two cross-sections based upon contours 100 ft. apart. Both are made on semi-transparent paper as described. When the cross-section nearest sea level is placed upon the other, sea level lines coinciding, correlations can be made and checked in the third dimension. One literally sees uphill and into the rising structure. In this manner the third dimension of the old fashioned and clumsy peg model is equalled.

Throughout all correlating, the engineer must be cautious about relying upon the accuracy of graphic well log strips constructed from cable-tool log books, or from modern rotary log records if the formation is drilled. Graphic well logs are good for fine distinctions in formation changes only if they are constructed from core records. A rotary driller's attempts to distinguish between siltstone, sandstone, conglomerate, hard and soft shells, and shale from the table speed, the rate at which the bit digs off on the weight indicator, and occasional screenings, are highly individual. So much more so was this true of cable-tool days. The presence of gas pressure and color in the case of oil sands made their drilled determinations more nearly accurate, however, and correlations had best be limited to them, if core records are not available.

Engineering practice will, of course, vary with the operator and geological conditions. We chose cable tools as the method for working over our old wells for two reasons. Primarily, it is less expensive than rotary. It is evident from the outset that the margin of profit arising out of stripper well deepening will be small, even that gross receipts will be small; therefore, costs are vitally important. Hole is made faster with rotary, but the usual maximum of 300 ft. of deepening in this work is not the only item. Total labor then looms large; two men versus five makes a considerable difference. The old style standard pumping rig equipped with motor or engine, band wheel, bull wheel, calf wheel, and walking beam points to cable tools as much easier and less expensive to rig up than if the whole is converted to rotary pumps, pit, crown, hoist, and table. The punch cores obtained with a cable-tool core barrel are satisfactory where the geology is known and marker beds the principal interest.

Secondly, the use of cable tools is indicated by the nature of the sand in which deepening will take place. Remember that the general area is depleted, that there is very little formation pressure, that a low static fluid level exists above which the sand will take water as long as the operator cares to run it in the hole. Such a condition demands that every care be taken to prevent loss of circulation into the formation. Using rotary pump pressures, this is likely to happen, and once forced in, the mud and water, which possess a capillary affinity for interstices some three times that of oil, are most difficult to get out. No initial pressure can be relied upon to blow the well in and clean it out, but the small amount of mud used with cable tools minimizes this danger.

All in all, the exactitude required in this reconstruction work, the painstaking effort, the scope of activity embraced, and the results make the petroleum engineer's task an interesting and challenging one.

Sulfamic Acid Now Produced Commercially

COMMERCIAL production of sulfamic acid, a new inorganic acid having the form of a crystalline solid was announced by Martin E. Cupery, research chemist of E. I. du Pont de Nemours and Company, before the 95th Meeting of the American Chemical Society at Dallas, Texas. This new acid is colorless, odorless, non-hygroscopic, and non-volatile. It can be shipped and handled with all the convenience of a solid, yet when dissolved in water it has the characteristics of a strong, highly-ionized acid, approaching hydrochloric and sulphuric acids.

Although identified about 60 years ago, sulfamic acid has never before been produced on a commercial scale because of lack of a practical process of manufacture. The new process, which was discovered independently at the same time in Germany and in the United States, and which is covered by patents here and abroad, is based on urea and fuming sulphuric acid. Although prepared from the organic compound urea, sulfamic acid itself is inorganic. In this respect, and because of much greater strength, it differs from such acids as lactic, acetic, formic, tartaric, and oxalic, to which group it is expected to be an important addition on the chemical market.

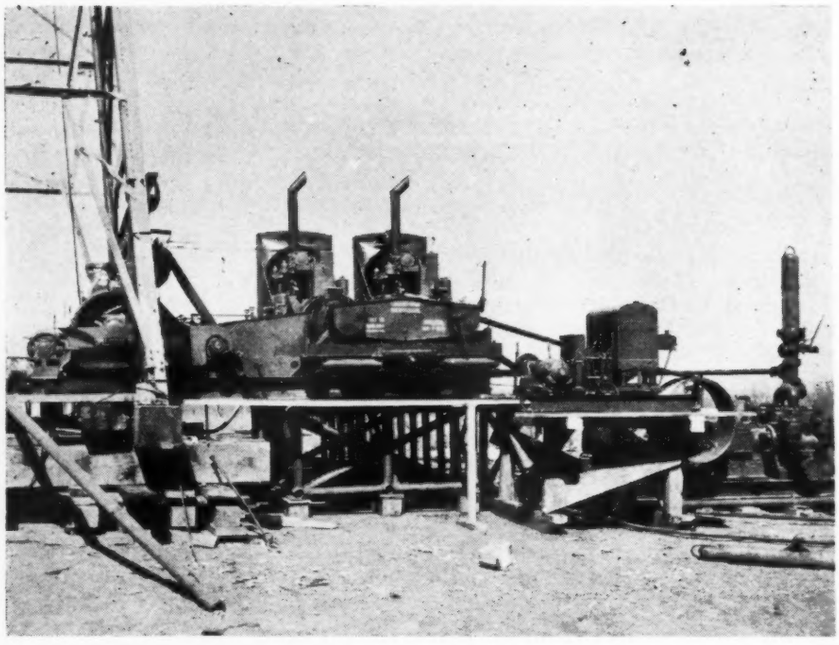
The original synthesis of the compound urea, which is employed in this new process, was a significant milestone in chemical progress. In 1828 the German chemist Wohler discovered that urea, once thought to be only of animal origin, could be made from ammonium sulphate and potassium cyanate, chemicals of the mineral kingdom. This discovery bridged the gap between "organic" and "inorganic" compounds, destroying the old idea of "vital force" as a factor in chemistry, and laying the foundation for modern chemical synthesis. The cycle is reversed in the present development, which converts urea (now produced synthetically in large quantities from ammonia and carbon dioxide) back into the inorganic realm to form a new inorganic compound for use by the industrial chemist.

Because of unique physical and chemical properties, sulfamic acid and its derivatives are expected to be instrumental in improving processes and reducing costs in a number of industries. For example, one potential use of the acid, which is now being evaluated by the dye and pigment industries, is for removing excess nitrites following diazotization reactions.

Salts formed by sulfamic acid with metals, including lead, barium, and calcium, are water soluble. The organic amine salts of sulfamic acid, such as quinine sulfamate, are considerably more soluble than corresponding salts of sulphuric and hydrochloric acids. These properties, Dr. Cupery said, are a significant factor in a number of possible commercial applications.

Dr. Cupery disclosed that ammonium sulfamate, a derivative of sulfamic acid, is the fire retardant announced by the du Pont company last year. Ammonium sulfamate is said to be unusual among flameproofing salts because it does not cause stiffening nor otherwise adversely affect the handle and feel of fabrics and paper, and because it shows no tendency to effloresce to the surface upon prolonged storage. Furthermore, the fact that ammonium sulfamate shows less tendency than other inorganic salts to coagulate colloidal solutions indicates the possibility of flameproofing materials that have previously resisted treatment.

Other derivatives and reactions of sulfamic acid are of probable importance in the dye, pigment, textile, laundry, tanning, wood preserving, and petroleum industries.



Typical gas-gasoline motor-driven rotary drilling rig

depending on the thickness of the lime zone. The sand, naturally, is not treated with acid. The recent trend has been to reduce the quantity of acid used and to increase the pressure at which it is introduced, thus forcing the acid outward through the small channels to enlarge them rather than the well bore itself.

Electrical logging has been introduced and results have been reasonably satisfactory. One gun-perforating truck has been stationed in the field for about a month and casing has been gun-perforated in a few wells.

The field has been developed in an orderly manner, wells being drilled on a 20-acre spacing pattern. There has been no hot oil produced, and only a very few wells have been drilled on

Orderly Development Characterizes

By RALPH H. KING

THE discovery of a deeper producing zone in the Strawn group in the old K. M. A. field, Wichita and Archer counties, Texas, was overshadowed by the discovery and rapid development of the East Texas field. As a result, only a few wells were drilled to the deeper zone until the latter part of 1937. In a way, this situation benefited the operators in the K. M. A. field, as shown by the fact that wells drilled recently are better equipped, more advantageously finished, and produce at higher rates than the early wells in the field. Although some difference in the rates of production is caused by differences in lithology, thickness, or structural position of the producing formation, nevertheless improved engineering technique must be given its full share of the credit.

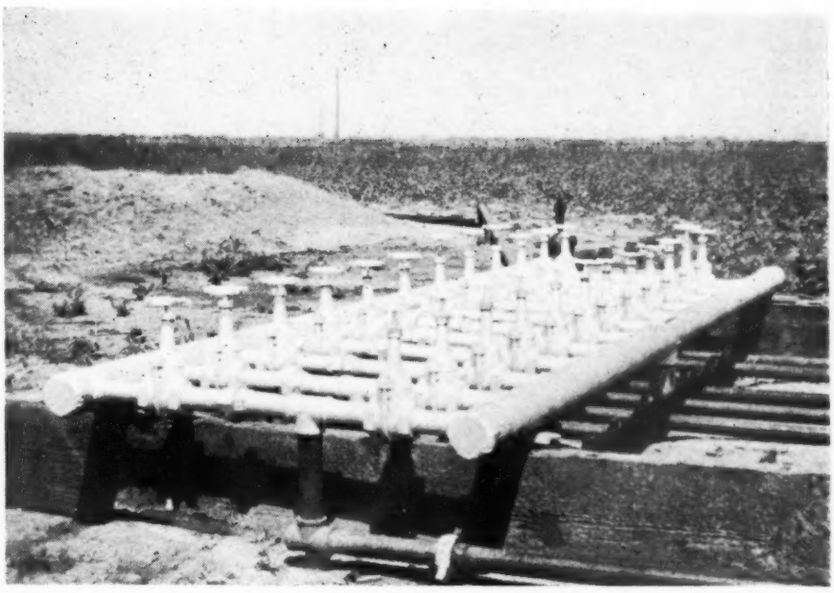
Most wells are drilled with rotary tools to the top of the producing zone, 7-in. O. D. casing set and cemented, and the well drilled-in with cable-tools, some form of "spudder" or clean-out machine usually being employed. A few wells, however, have been drilled-in with rotary tools, clear water or oil replacing the mud fluid. Oil is used for the final cleaning. Circulation downward through the annular space and upward through the drill pipe has been attempted but in one well in which an ordinary bit was used for drilling, the bit became clogged. The system is feasible and has the advantage of upward flow at high velocity because of the reduced cross-section of the flow channel, so it will probably receive further trial in the area.

After being drilled-in, the producing zone in most wells is shot with 80 to 750 qt., 350 qt. being a fair average. Some wells are not shot but are treated with acid, the quantity used

Well-head hook-up on Kadane-Griffith No. 1 Mangold

tracts smaller than 20 acres. The bottom-hole pressure, however, is very irregular and appears to be declining rapidly. It is to be expected that the pressure in the early wells would have declined appreciably, and it has. It is now less than 1200 lb. per sq. inch. The highest pressures exceed 1600 lb., but the distribution of high and low pressure is independent of the age of the wells, there being a small area of very low pressure within a short distance of the area of highest pressure, all wells in this part of the field having been drilled in the last six months. The Railroad Commission gauges show that bottom-hole pressures in some wells have declined more than 140 lb. and in other wells have increased a similar amount. Most wells have shown a decrease but on leases that are being repressured the decrease has been only a few pounds.

The gas/oil ratio is fairly uniform and is approximately 430 cu. ft. per barrel. The gas is all in solution at the present bottom-hole pressure, and most wells are flowing. It is estimated that the wells will cease to flow when the pressure declines to 700 lb., the calculation being based on a sub-sea depth of 2600 feet. At the present rate of decline it will be only a relatively



Manifold used by Petroleum Producers Company

short time until the wells must be pumped.

The depth of the wells is thought to make central power pumping impracticable. The wells now pumping are equipped with pumping units driven by gas engines or Diesel engines. The cost of a unit to pump a 3800-ft. well is about $3200.

Well potentials are high and production is restricted to 58 bbl. per well. Hence most wells can produce their allowable in a few minutes. Some operators prefer to hold back-pressure on the wells and produce the oil at a low rate to minimize the cooling effect of the expanding gas, as the oil contains a large amount of paraffin, which is deposited in the tubing or casing. Other operators prefer to flow the wells "wide open" for a short time in order to blow out the paraffin. Sufficient data are not yet available to determine which method is preferable, but it is obvious that paraffin deposition will reduce the rate of flow of most wells and that methods to counteract it must be developed soon.

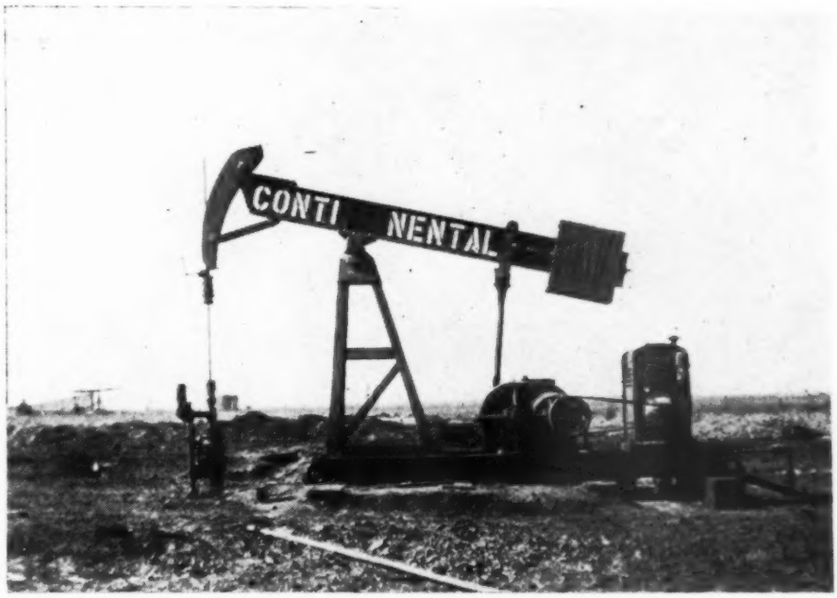
The gravity of the oil is about 43 deg. A. P. I. and the gasoline content is about 40 percent. Hence the gas accompanying the oil has a high gasoline content. At present separator pressures are comparatively high but the gas is yielding 2.5 to 3 gal. of gasoline per thousand cu. feet. When all gasoline plants are completed the separator pressure will be reduced and the gasoline yield will be increased somewhat as the heavier gases now being retained in the oil are allowed to vaporize.

The gasoline plant operators have devised a plan for returning residue gas to the producers for use in repressuring. As previously stated, some plants are still under construction, so the plan has not been put into effect throughout the field, but some leases are being repressured at present, and it seems probable that many more will be when the gas is available. The residue gas will be returned to the producer at whatever pressure he specifies below 750 lb., the cost to him being based on the pressure at which the gas is supplied to him. The scale of prices should make the plan attractive, particularly to small operators owning scattered leases. Extensive application of repressuring will effectively retard the pressure decline and prolong the period of production by natural flow.

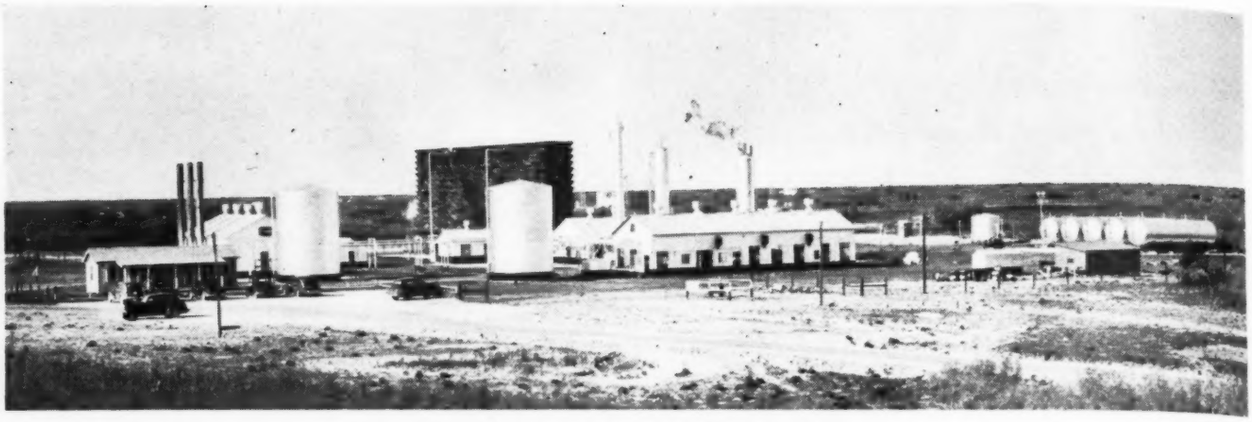
Engineering methods have been greatly improved in the years that the development of the field was suspended, but more important has been the realization of the necessity of conserving reservoir energy that prompted the plans for extensive repressuring, and the realization of the wastefulness of excessive and unnecessary drilling that impelled strict adherance to the Railroad Commission spacing regulations. Even more important has been the maintenance of the price structure by compliance with orders restricting production. The K. M. A. field is an outstanding example of orderly development by coöperative agreement for the profit of all concerned.

K. M. A. Field » » »

Excessive drilling, open flow, and other wasteful practices have thus far been avoided—repressuring already being applied to conserve reservoir energy



Pumping unit on one of the deep wells



General view of Flour Bluff gasoline plant

New Gasoline Plant is Compressor-Absorp

By FRANK H. LOVE

THE newly-constructed Flour Bluff Gasoline Plant, owned jointly by the Humble Oil and Refining Company and the Barnsdall Oil Company, and operated by the former, is a combination compressor-absorption and well-pressure-absorption unit. It is situated 12 miles southeast of Corpus Christi, Nueces County, Texas, in the Flour Bluff oil field. The plant was constructed to process gas produced with oil and has a capacity of 15,000,000 cu. ft. per day.

Gas from wells having a low gas-oil ratio is handled by compressors and that from wells having a high gas-oil ratio is brought to the plant under a well-pressure of approximately 35 pounds. Three main gathering lines, one 10-in., one 12-in., and one 16-in., transport gas to the plant from the wells having a low gas-oil ratio. The lines converge at the plant and the gas is metered through a common master meter. The gas then passes through a 96-in. by 12-ft. vertical-type scrubber, which is equipped with a scrubbing element for separating the liquid from the gas, as well as a mercoid float to shut down the compressor plant should liquid rise above a predetermined point in the scrubber.

The compressor plant, to which the gas is next sent, consists of three vertical, V-type, 8-cylinder compressor units, each equipped with four 18-in. compressor cylinders. These units are designed to operate from 12-in. Hg (mercury) vacuum intake and 40-lb. gauge pressure discharge. The combined capacity of the three units is approximately 8,000,000 cu. ft. of gas per day. Each is equipped with conventional relief valves and by-passes, as well as a magneto arranged to short out if (1) the engines overspeed, (2) the cooling water becomes too hot, or, (3) the pressure in the lubricating system drops. Each unit also has an air filter of the oil-bath type.

Lubricating oil used in these compressors is recleaned by centrifuging. The centrifuging systems consist of built-in pumps that draw the used oil from the compressor units. The oil is then heated to a temperature of approximately 180 deg. fahr., by means of exhaust steam, and is centrifuged to eliminate solids and water, after which it is pumped to a "lube" tank of which there is one on each compressor.

Every operating condition in the compressor plant is accurately indicated or recorded on the gauge board, which contains instruments for showing the following: (1) indicating starting air; (2) fuel gas manometer; (3) indicating gas discharge pressure; (4) gas discharge pressure recorder; (5) indicating jacket water pressure; (6) gas suction manometer; and, (7) gas suction pressure recorder.

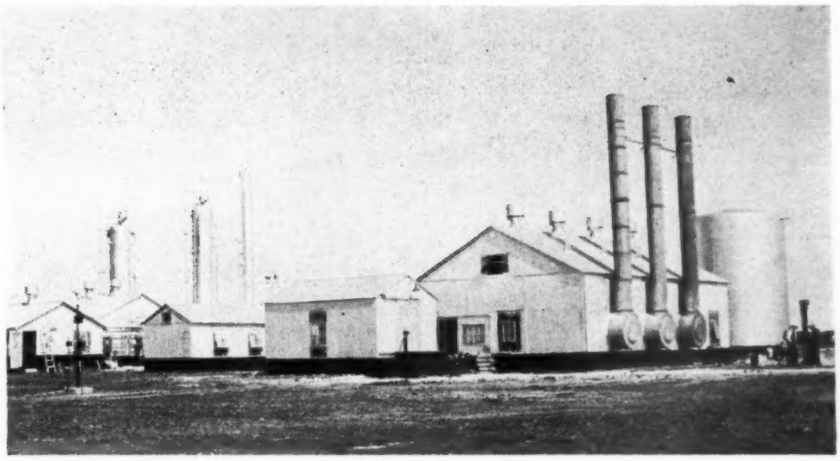
The cooling system for the compressors is of the closed type, making use of atmospheric cooling sections situated in the cooling tower. Water is circulated by a steam-driven centrifugal pump. This pump and a spare are in the auxiliary building, which is a part of the compressor building, being separated from the compressor units by a gas-proof wall. Also in the auxiliary building are two 25-kva. electric generators, powered by V-8 engines.

All headers, including the gas suction header, the gas discharge header, the cooling water header, and the fuel gas header, are in an open concrete trench immediately outside the building. An 18-in. line takes the gas from the vacuum scrubber to the gas suction header in the trench. After the gas leaves the compressors and enters the discharge header it is received by a 12-in. line and discharged through a 60-in. by 8-ft. vertical-type scrubber. From this scrubber the gas enters the atmospheric-type coolers.

Gas from wells having a high gas-oil ratio is brought to the plant through a 10-in. line. The gas is cleaned in a 42-in. by 8-ft. vertical-type scrubber, after which it is combined with the cooled compressor gas and enters the base of a 72-in. by 39-ft., 20-tray absorber, equipped with mist extractor. Residue gas from the absorber is scrubbed in a 66-in. by 10-ft. scrubber, which is baffled to provide efficient gas and oil separation. At the present time the residue gas is used for plant fuel and for field purposes.

Enriched oil from the absorbers is picked up by a steam-turbine-driven centrifugal pump and discharged through heat exchangers into a hot-oil vent tank. Vapors from this tank

Boiler house, building housing water-treating equipment, shower and locker room, and oil pump house. The last contains the oil-circulating pumps, stabilizer pump, and reflux pump

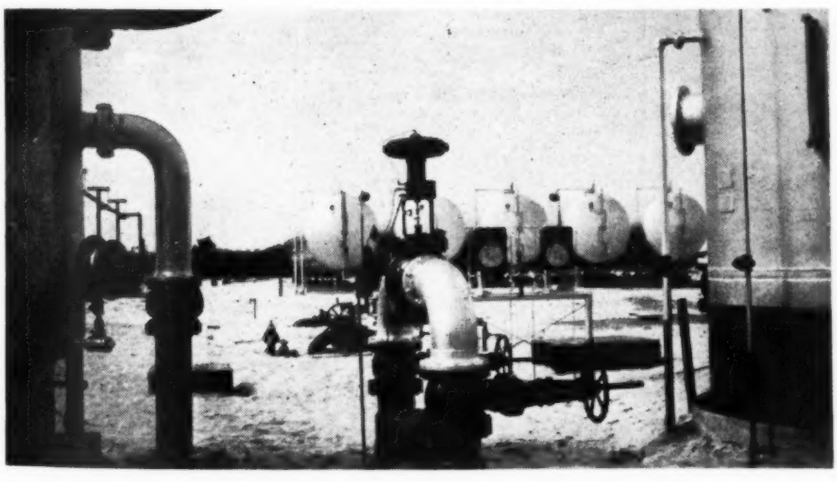


tion and Well-Pressure-Absorption Unit

Flour Bluff plant in Nueces County, Texas, has capacity of 15,000,000 cu. ft. per day, processing gas produced with oil

are mixed ahead of the gas coolers with gas discharged from the compressors. The liquid from the hot-oil vent tank enters a steam pre-heater. The oil, upon leaving the steam pre-heater, goes to a 60-in. by 42-ft. combination fractionating still and rectifier. The still contains 18 active bubble plates and one water tray. Vapors from the still-rectifier are cooled by primary condensers of the atmospheric type, then enter a 48-in. by 8-ft. primary accumulator. Uncondensed vapors from this accumulator pass through final atmospheric condensers into a 72-in. by 18-ft. final gasoline accumulator. Vapors from the latter are tied into the gas stream entering the absorbers. Gasoline from the accumulator is stabilized in a conventional 30-tray, 30-in. by 54-ft. stabilizer. The stabilizer feed and reflux are handled by close-clearance steam reciprocating pumps. The finished gasoline is stored in five 10-ft. by 40-ft. tanks.

The denuded oil from the still enters five heat exchangers connected in series and having a total surface of approximately 6100 sq. feet. From there the lean oil enters atmospheric-type oil coolers having an approximate surface of 5600 sq. ft., going then to a 72-in. by 18-ft. lean oil surge tank. A steam-driven centrifugal pump takes suction from this tank. A steam-turbine-driven centrifugal pump serves as a standby both for the rich and lean oil pumps.



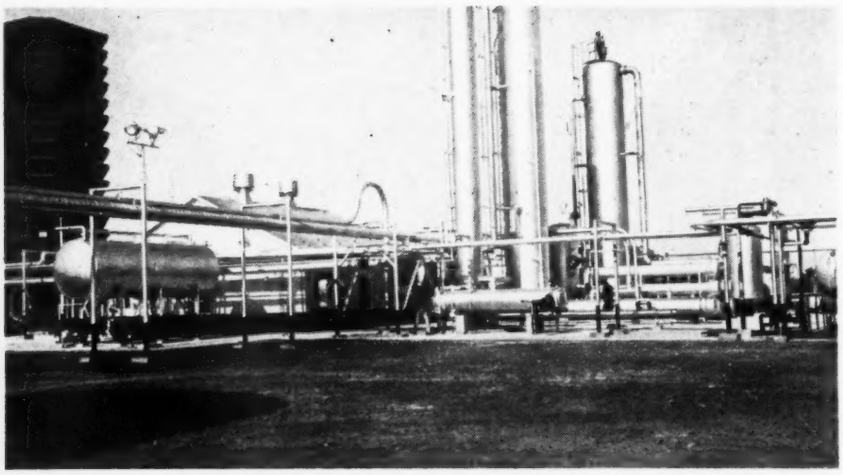
Absorber back-pressure regulator and gasoline storage tanks

The reflux necessary to hold top temperature on the still rectifier is obtained from the primary condenser accumulator of the still, being handled by a steam reciprocating pump.

Three centrifugal oil pumps, two still reflux pumps, and the three stabilizer pumps are housed in one building. Also in this pump house is the instrument panel board on which are installed the following instruments: stabilizer feed, recording flow controller, stabilizer reflux, recording flow controller, stabilizer pressure, recording controller, stabilizer reboiler, stabilizer reboiler temperature controller, still top temperature, recording controller and bottom temperature recorder, lean oil flow recording controller, stabilizer top temperature recorder, absorber pressure recording controller, indicating instrument gas pressure, indicating steam pressure, and a seven-day clock.

In another building, situated near the cooling tower, are two turbine-driven water pumps. One is used for circulating water over the tower in which are installed the atmospheric-type coolers and condensers. The other pump is a standby.

Steam used in the operation of the plant is generated by three 125-hp. oil-field, domeless-type boilers. Steam



Distillation equipment, stabilizer, absorber and still, pump house, and north end of cooling tower

pressure on the boilers is 200 lb. per sq. in. gauge. Water and fuel regulators are a part of the boiler equipment. The boiler-feed pump is of the reciprocating type, steam-driven. The main steam header is provided with an orifice meter for measuring the volume of steam. The boilers are equipped with continuous blow-down valves. At four strategic points in the plant yard emergency valves have been placed, making it possible to shut off the supply of fuel gas to the boilers and introduce steam into the fire boxes in event of a fire or threatened fire. At these same points throughout the yard are placed valves for shutting down the compressor plant by shorting-out the compressor magnetos.

The disposition of the finished gasoline from the plant is by tank car. A three-car loading rack has been constructed at Corpus Christi and extending to it is a 2½-in. loading line.

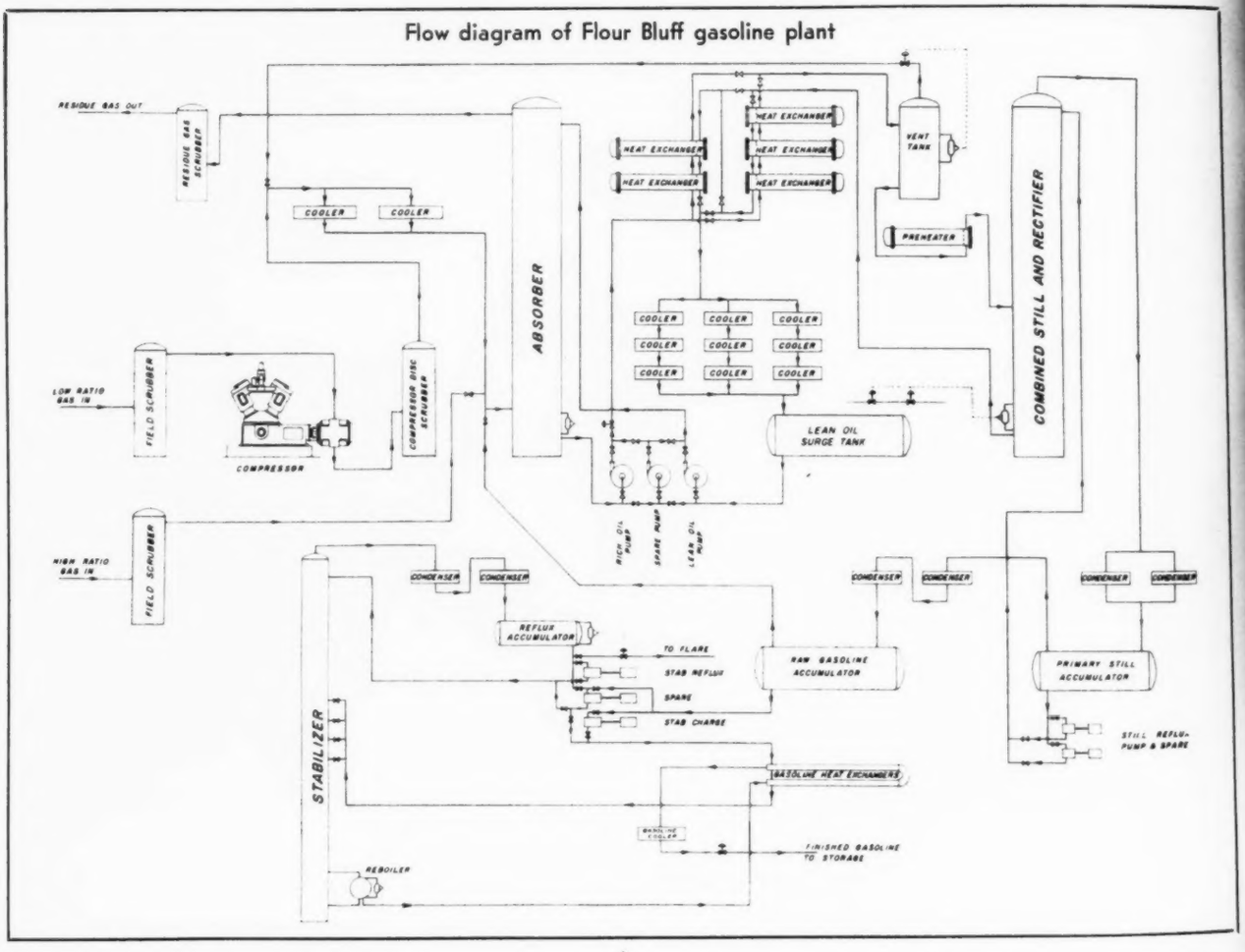
The redwood cooling tower is designed to cool the lean oil, still overhead, compressor gas to the absorber, and stabilizer reflux to within 10 deg. fahr. of wet bulb of 80 deg. fahr. with zero wind velocity.

All towers, scrubbers, and other pressure vessels were built in strict accordance with the A.P.I.-A.S.M.E. codes and are so stamped.

TABLE I

Operating Pressures and Temperatures	
Absorber	35 lb.
Still pressure	45 lb.
Stabilizer pressure	175 lb.
Boiler pressure	200 lb.
Gas to absorber	75 deg. fahr.
Oil to absorber	75 deg. fahr.
Oil from pre-heater	380 deg. fahr.
Still top temperature	217 deg. fahr.
Reid vapor pressure	18 lb.
Specifications on Absorption Oil	
Gravity	41.0
Molecular weight	170.0
Initial	350.0

Flow diagram of Flour Bluff gasoline plant



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SMOOTH-RUNNING, BALANCED, V-DESIGN

SIMPLE 2-CYCLE, GAS-INJECTION TYPE

CHOICE OF 4, 6, 8, OR 10 POWER CYLINDERS

400 TO 1000 HP AT CONSERVATIVE SPEEDS

ALL IRON CASTINGS MADE OF MEEHANITE

THOROUGHLY ENGINEERED BY COOPER-BESSEMER

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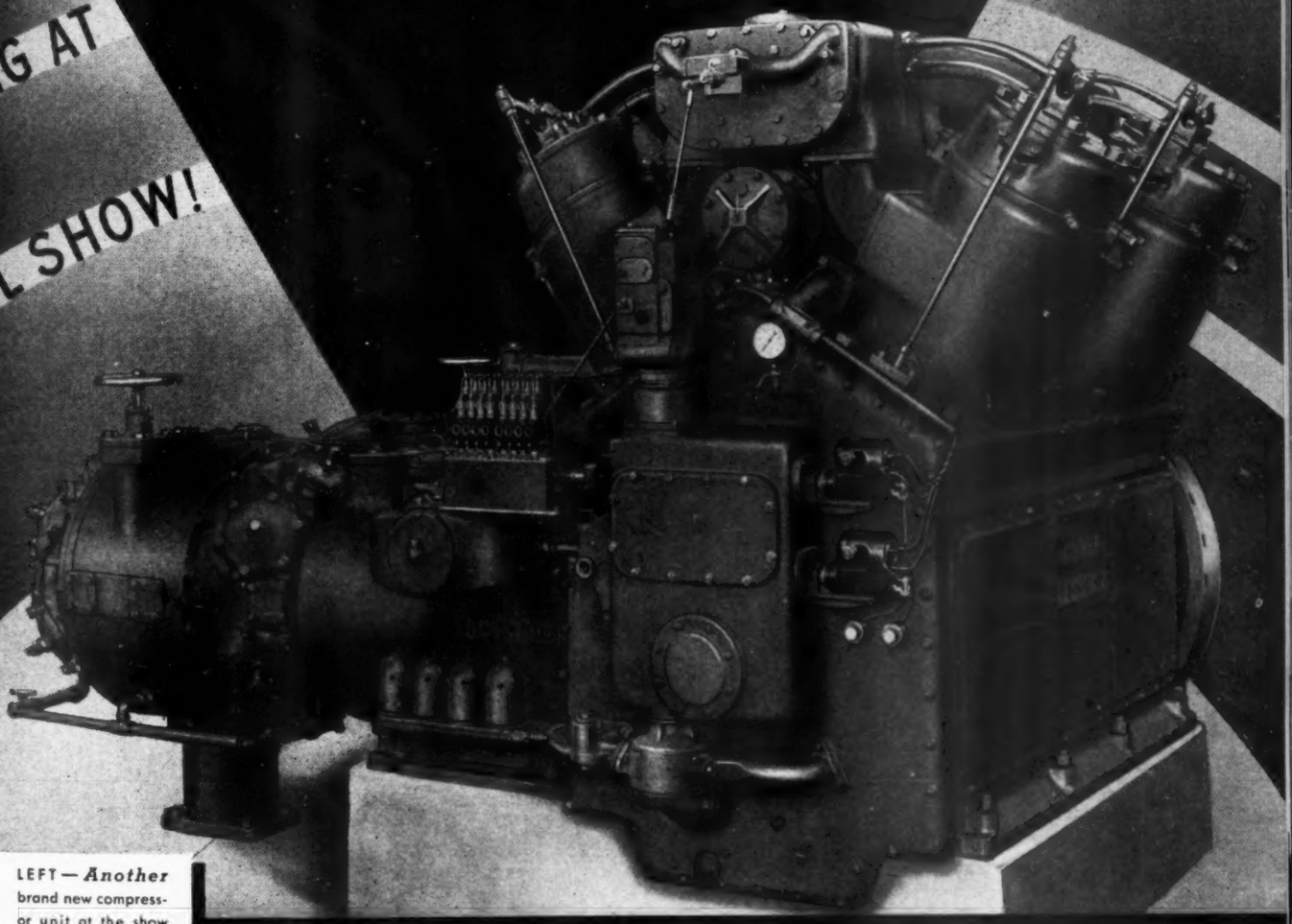

LEFT — *Another* brand new compressor unit at the show ... Type G-MS! Two-cycle, 40-50 hp. Self-contained. Combines vertical gas engine with compressor. Convertible for oil fuel.

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105 YEARS OF KEEPING PACE WITH INDUSTRY

Fig. 1. East side of the compressor building showing the discharge header arrangement

By

B. L. ROGERS
Superintendent of Compressor Stations

and

O. H. MOORE
Assistant Superintendent of Compressor Stations, Lone Star Gas Company

Decline of Well Pressures Makes New

DECISION was made late in the summer of 1937, after a careful study of the main line and field facilities, to construct a compressor station near Shamrock, Texas, to insure that the delivery capacities of these facilities would be available during a peak demand. The pressure in the Panhandle field for the last several years has shown a steady decline, being at a much more rapid rate during the period when great quantities of gas was being blown to the air. The pressure decline curve has flattened out since this wastage was stopped, but field pressures had been reduced to such a point that a station in this area became a necessity.

Because of the depletion of two other fields, most of the engines necessary to equip the Shamrock station were available at the plants in those fields, and as they were of the small horizontal type, 15 units were necessary to handle the required volume of gas.

The particular location was selected because the main line from the field crossed the highway at this point, and its proximity to the town of Shamrock made it unnecessary to construct several cottages and made available a good supply of water.

Compressor Units

There are nine units of 160 hp. each, and six of 170 hp., at 190 and 200 r.p.m., respectively. Each unit is of the twin-cylinder, 4-cycle, horizontal-type gas engine, direct-connected to 6-in. by 20-in. compressor cylinders. The compressor cylinders are to operate at a suction pressure of 200 to 225 lb., and a discharge pressure of 400 pounds. The capacity per unit at these pressures are, respectively, 3,900,000 and 4,480,000 cu. ft. per day.

The compressors had operated several years in other locations, and it was necessary to recondition them. This work was under the direction of the company's regular employees, transferred from other plants. (See Fig. 2.)

Exhaust and Air Intake Installation

The compressor units are equipped with air filters and the dry exhaust installation that we have used so successfully for several years. This design of exhaust installation, in which the exhaust pipe proper is encased in a jacket, effects a natural draft of air from the engine room. (See Fig. 3.)

Jacket-Water System

The engine-jacket water system is of the enclosed type, the make-up water being treated through a "green sand" Zeolite softener. This design, in which the water surface exposed to the air is held to a minimum, holds the evaporation so low that a household-type softener is sufficient to handle the make-up water. The water in the system is tested at regular intervals for hardness and corrosiveness. (See Fig. 4.) In addition to the Zeolite treatment, the corrosive effect of the water is controlled by an anti-corrosive treatment.

An orifice meter on the discharge side of the engine-jacket water pump records the volume of water in circulation, and a two-pen recording thermometer, placed at the cooling tower, records the temperature of the engine-jacket water entering and leaving the coils.

A constant level of treated water is maintained in a surge tank situated at the extreme north end of the compressor building. The jacket-water cir-

Fig. 2. View of engine room

culating pump takes its suction from this surge tank, pumps the water through atmospheric-type coils situated in the cooling tower, and from there to an inlet header in the engine room. After passing through the engines, the water returns to the surge tank through a header placed over the power end of the engines.

An orifice meter on the discharge side of the pump, handling raw water from the basin of the engine-jacket water section of the cooling tower, records the volume of water sprayed over the engine-jacket water coils.

In the lubricating system for the engines are inlet and return headers extending the full length of the engine room. After passing over the engines in operation, the oil drains to a concrete sump in the north end of the engine room. A circulating system, composed of two 3 by 2 by 3 duplex

General Layout of Plant

The general layout of the plant is such that the station can be placed on the line or removed from it with unusual ease. If the plant is down, for instance during a no-demand period, and it becomes necessary to place the plant in operation, it is only necessary to start the number of units required and then close the block gate in the main line between the points where the suction and discharge lines tie into the main line. The only time that this procedure could not be followed would be when the suction or discharge headers had been drained. If the plant is to be taken off the line, it is only necessary to shut down the engines, and, when the up-stream and down-stream pressures at the block gate equalize, open the block gate.

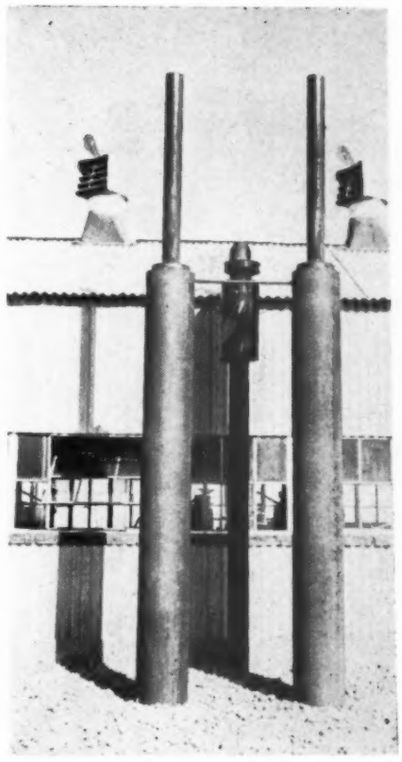


Fig. 3. Exhaust and air intake lines

Gas Compressor Station Essential

Construction and operating details of station at Shamrock, Texas, which assures capacity gas deliveries during peak demand

reciprocating pumps, maintains a constant pressure on the inlet oil header. This pressure is maintained regardless of the number of engines in operation, by a diaphragm pressure-control valve.

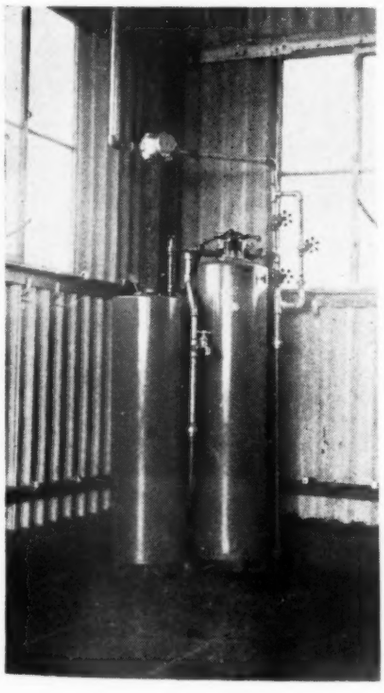


Fig. 4. Zeolite water softener

Gas Cleaners

Gas entering the plant passes through gas cleaners connected in parallel. It is then carried into the plant to the compressor units through an 18-in. overhead header.

The engine room floor is elevated above grade to permit the discharge connections from the compressors to extend aboveground from the building to the discharge header, the 18-in. header itself being just above grade. Relief valves of 1½ in. for each cylinder are placed on the discharge connections outside the building. These relief valves are set to relieve at 450-lb. pressure.

The gas passes from the discharge header through atmospheric-type cooling coils in the cooling tower, thence through an outlet scrubber, and into the main line. A two-pen recording thermometer, mounted at the cooling tower, records the temperature of the gas entering and leaving the cooling coils.

An orifice meter on the discharge of the circulating pump, records the volume of raw water sprayed over the gas coils.

A thermometer recording the ground temperature has been installed adjacent to the gas-recording thermometer as an operating guide, for the gas leaving the plant is kept as near ground temperature as possible.

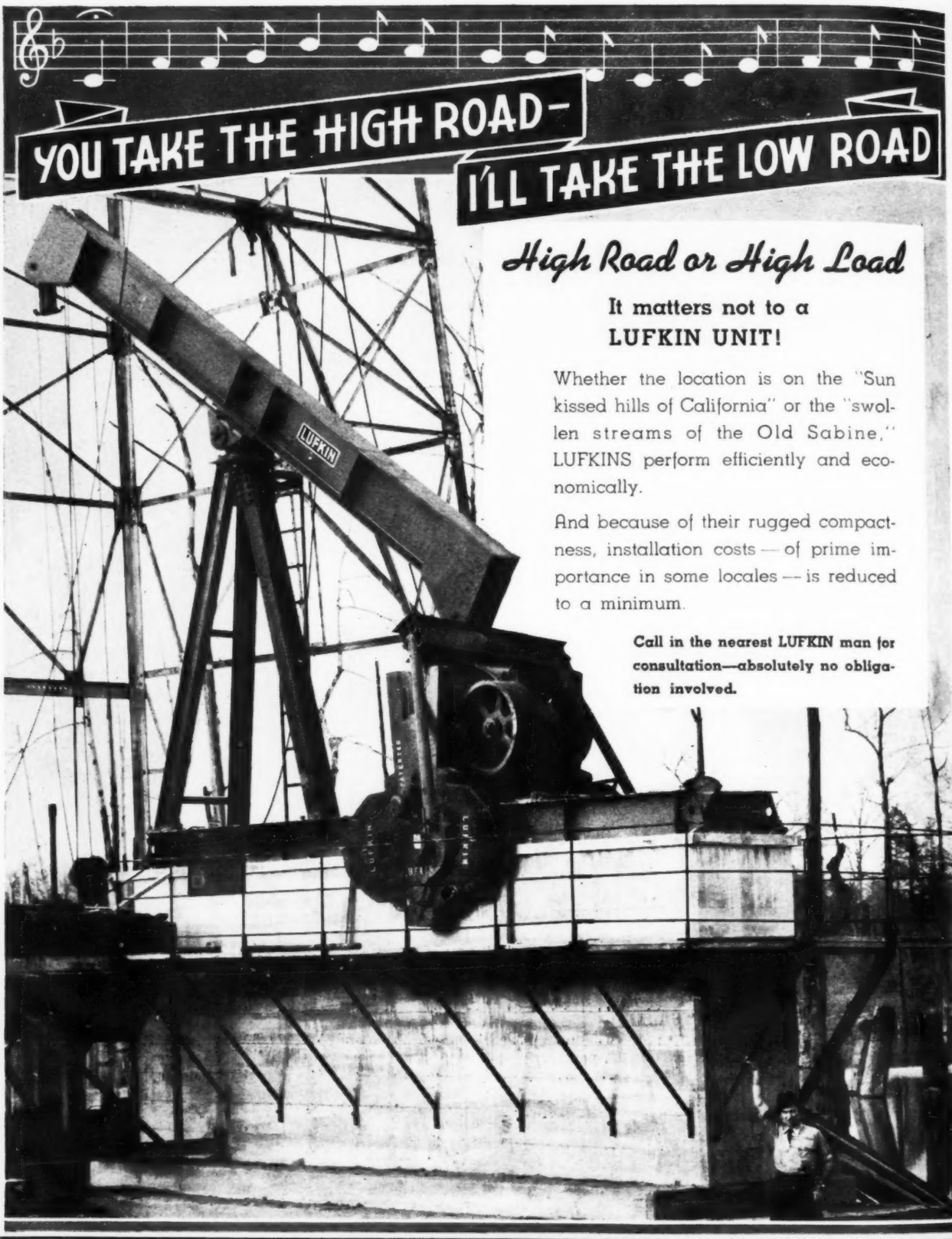
Cooling Tower

The cooling tower selected for this plant is of the induced draft type, constructed in two sections. Two-speed fans situated in the top of the tower pull air in through the louvers at the base of the tower. The tower proper is constructed of redwood, having double casing to insure tightness. Each section has two spray systems, the water spraying upward. A secondary spray system is constructed in each section in such a manner as to transfer the water that would normally run down the sides of the tower back on to the coils. (See Fig. 5.)

The arrangement of a bank of coils in the base of the tower, two-speed fans controlling the volume of air moving through the tower, and positive control of the water in circulation gives as flexible operation as it is possible to obtain.

Instruments

The gauge board in the engine room has indicating and recording gauges



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LUFKIN PUMPING UNITS

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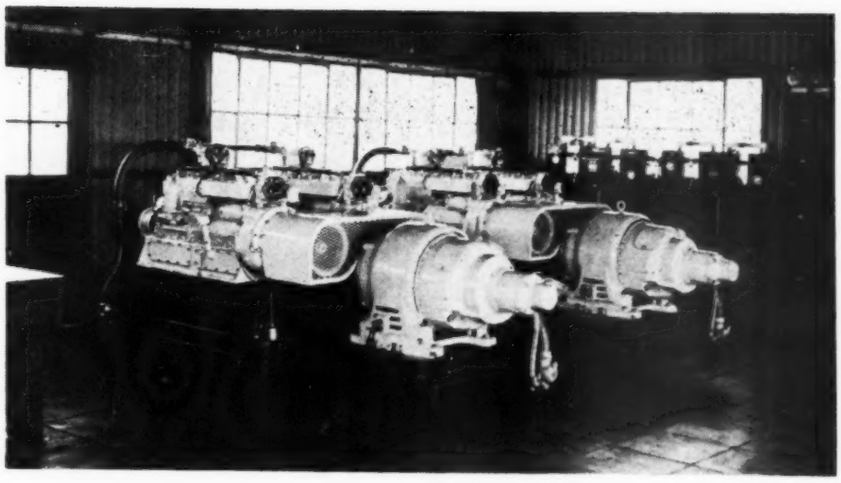
Fig. 6. Two 60-kw. dual-engine, high-speed generating units provide electric power for the plant



for suction and discharge pressures, time clock, and indicating gauges for starting-air and jacket-water pressures. The gauge board is of enameled thin sheet iron, and all gauges are of the flush mounted type. It is situated near the center of the engine room on the compressor cylinder side of the building, permitting the operators to be in the approximate center of activities.

The recording thermometers and orifice meters provide a continuous operating picture for the chief engineer, and are supplying valuable operating data. With this equipment, it is possible to check quickly the performance of the individual pieces of equipment as well as that of the plant.

Auxiliaries

The auxiliary equipment supplying lights and electric power for the circulating pumps consists of two 60-kw. dual-engine, high-speed generating units. Each consists of a 60-kw. generator, V-belt driven by two 54-hp., 8-cylinder, vertical gas engines. A vacuum-operated clutch, which may be cut in or out at will, makes either engine start or stop automatically as the load varies. Each engine is equipped with automatic shut-down devices to protect the units from high oil or water temperatures. (See Fig. 6.)

There are in operation continuously three motor-driven centrifugal pumps. Two handle the raw water in the two sections of the cooling tower and the third the treated water through the engine jackets. A fourth pump is provided and manifolded in such a manner as to provide a standby for either of the three other pumps. (See Fig. 7.)

A gas-fired, low-pressure boiler is installed in the auxiliary building to provide steam for the unit heaters in the engine room and auxiliary building.

A modern wash room is in one corner of the auxiliary building for the convenience of the employees.

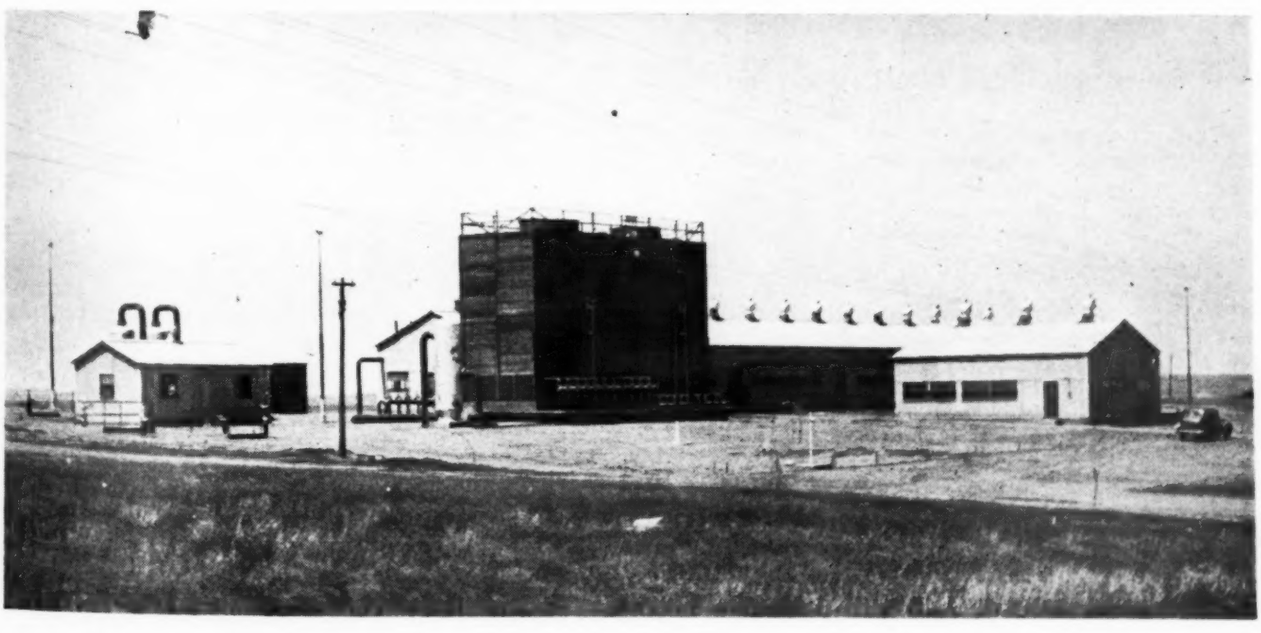
The starting-air V-type compressor situated in the auxiliary building is driven by a gas engine equipped with an automatic-pressure-actuated stop switch. Starting-air receivers are placed aboveground alongside the auxiliary building.

Construction

The main engine room and auxiliary buildings are of structural steel construction, sheathed with corrugated asbestos sheathing. The framing for these two buildings was transferred from the two plants from which the engines came. The fuel meter house and garage are of wood framing, covered with the same material as the main building. The plant office and the chief engineer's cottages are frame structures covered with asbestos shingles.

All electrical conduits and fixtures in the compressor building room and

Fig. 5. View showing the induced-draft type cooling tower in place



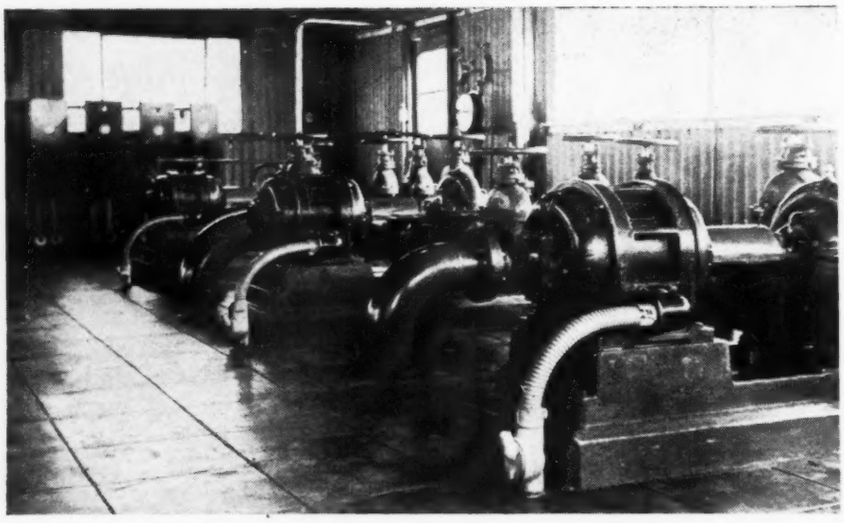


Fig. 7. Circulating pumps

hours of exposure without a lost-time accident.

Welding ells were used in all of the aboveground piping in sizes of 4 in. and above. All bends under 4 in. were made on the job by one of our old employees who has become an expert in this line. Before a welder was permitted to make a weld in the plant he was required to qualify under the A.P.I.-A.S.M.E. welding test. The value of this rigid welding qualification was proved when only two small leaks showed up during the 500-lb. hydrostatic tests made on the suction and discharge headers and connections.

the fuel meter house are explosion-proof. The control panel for the lights and heater motors in this building is situated at the nearest adjacent point to the auxiliary building.

Floors are laid off in 18-in. squares, finished in slate grey, troweled to a smooth finish, and waxed.

The design and specifications for the station were prepared by the Lone Star's engineering department. Actual construction was under the supervision of C. W. Cardwell, assisted by field engineer A. B. Hamphill, with J. N. Carpenter in charge of welding. The station was constructed in 43,783 man

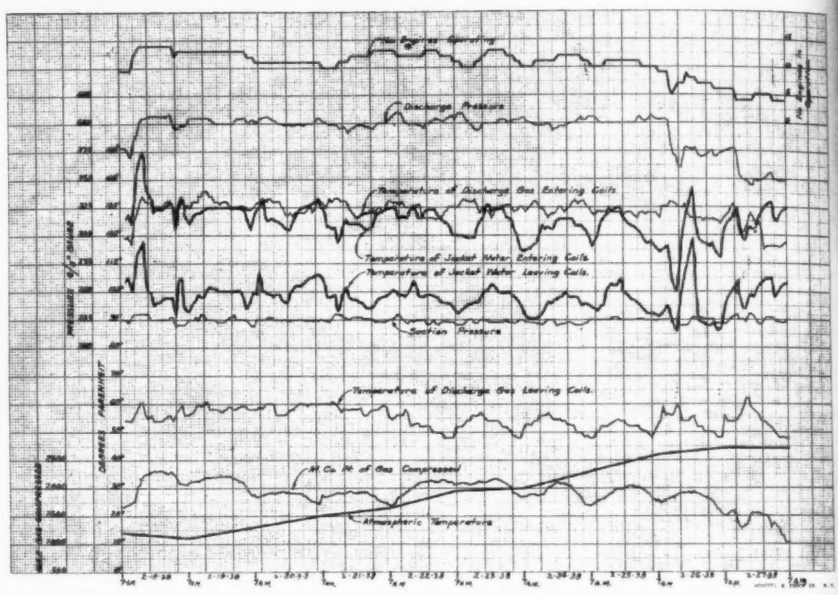
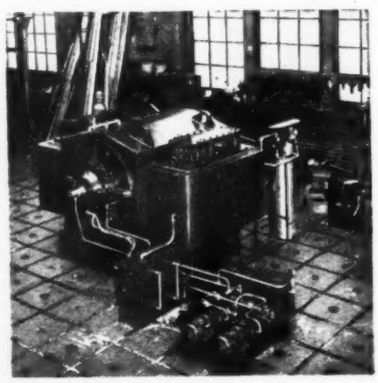

Discharge Pressure
Temperature of Discharge Gas Entering Coils
Temperature of Jacket Water Entering Coils
Temperature of Jacket Water Leaving Coils
Suction Pressure
Temperature of Discharge Gas Leaving Coils
Atmospheric Temperature

Fig. 8. Curves showing hourly operating data for a ten-day period at the Shamrock Compressor Station

Unusual Motors for Oil Refinery

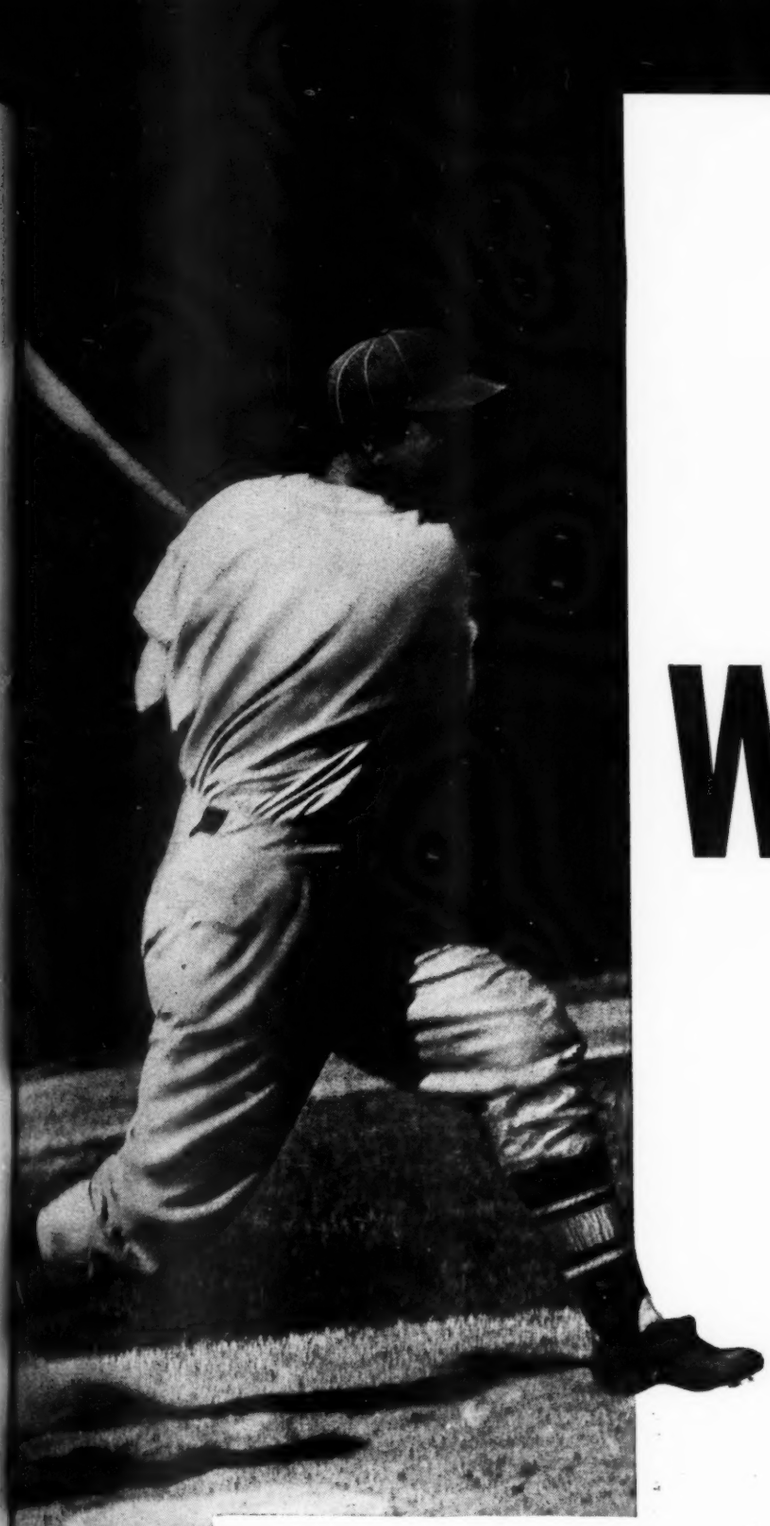
THE first two motors of their type and construction, involving, according to the manufacturers, one of the most unusual induction motor designs ever built, have been constructed by General Electric Co., Schenectady, New York, for oil refinery service. These are two-pole, 50-cycle induction motors, rated 1000 hp. at 3000 r.p.m., and are being installed by C. F. Braun and Company for Richfield Oil Corporation Refinery at Watson, California. Inasmuch as a motor of such size is beyond the range of labelled explosion-proof Class I Group D design, these motors are provided with a closed-circuit system of ventilation incorporating surface air coolers for removing heat, as well as a valve arrangement for continuously injecting a small amount of inert gas. These features, together with tight enclosures



and special seals, provide the operator with a complete arrangement for maintaining a non-inflammable atmosphere, slightly above atmospheric pressure, within the motor.

The closed-circuit cooling system, which is unusual for high-speed induction motors, involves directional ventilation; highly efficient propeller-type fans designed in the General Electric Research Laboratory force the inert mixture over the motor windings through ducts, and thence through surface coolers that extract the heat before the mixture is again circulated.

A force-feed lubricating system supplies oil to the bearings under pressure by means of two pumps. These pumps operate continuously to maintain a liquid seal at the bearings at all times.



PICK A WINNER!

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Bleaching Clay

Part 9

By RAFAEL FUSSTEIG

Dewaxing by means of the adsorption process

As known, paraffin wax distillate contains the paraffin wax in three forms, needles, plates, and amorphous particles, the needles being the easiest to separate from the mother oil. One of the most important factors influencing the size of crystals is the viscosity of the mother liquid. The more viscous this liquid, the smaller the crystals. In addition, tar and resin act as inhibitors to the growth of crystals. These inhibitors are adsorbed on the surface of the minute wax particles, increasing their surface tension. This causes them to become surrounded by a protective film of oil that prevents the ready growth of the crystals; therefore, the refiner seeks a wax distillate having a proper viscosity and free of the above-mentioned inhibitors. The use of pipe-still distillation has improved the stock in some respects. An exact fractionation between the hydrocarbons and inhibitors of tarry and resin-like nature is accomplished. The inhibitors are condensed in the bottom of the fractionating tower, and the paraffin wax distillate leaves the tower as vapor, being condensed in an air- or water-cooled condenser; however, the mother liquid of the paraffin wax distillates obtained in this process shows a high viscosity and in consequence the wax is crystallizable with difficulty. Especially in the fraction over 0.895 at 15 deg. cent. it is a very difficult matter to separate the wax from the mother liquid. The dilution of this wax distillate with gasoline increases the capacity for crystallization, but the pressed paraffin wax concentrate causes great difficulty during the wax-sweating process. The reason for this is that the wax particles are crystallized in plates. During the sweating process the paraffin wax concentrate can not be favorably sweated if the paraffin wax is crystallized in plates because the sweating oil is held back by the platy particles, making rapid filtration impossible.

Furthermore, when the heavy wax distillate is filtered the dewaxed mother liquid is not free of paraffin wax. It contains a small amount of paraffin wax in the amorphous form. The concentration of such a filtrate into cylinder stock results in concentration of the paraffin wax, which impairs the quality of the lubricating oils produced from the filtrate. Therefore, before using these lubricating oils it is necessary to dewax them; however, the fine crystalline structure of the paraffin waxes does not permit separation from the viscous oil by filtration even though the oil is dissolved in gasoline.

The reason is that the wax particle is surrounded by two protective films, the first or exterior film consisting of substances of tarry and resin-like nature, and the second or interior film, which is in direct contact with the paraffin wax particle, consisting of certain highly viscous hydrocarbons. These two films, on account of their high surface tension, cause the particle to remain in the amorphous form. After the first film is destroyed by the pipe-still distillation, the surface tension decreases somewhat, resulting in the growth of crystals in the form of plates.

When the heavy dewaxed oils are diluted with gasoline, the paraffin wax particles will crystallize in plates, because the second film of highly viscous hydrocarbons surrounds the surface of the wax particles; however, when any hard substance is added to the unfiltrable heavy oils as a filter aid, the impermeable pressed structure of the amorphous wax particles becomes porous and permeable. This filter-aid acts as a framework, a reinforcement whereby the fine, plastic, compressible solid to be removed is retained in a subsequent washing and drying. Diatomaceous earths have been used extensively for this purpose, and during the last several years considerable attention has been given to use of these materials in petroleum dewaxing.

To illustrate the effect of filter-aid addition, a narrow cut "overhead" lubricating distillate from Mid-Continent crude, of 49 Universal Saybolt seconds viscosity at 210 deg. fahr., and having 100 deg. fahr. initial pour test, could not be handled by the conventional methods of dewaxing. The distillate was diluted with 65 percent naphtha of about 58-deg. A.P.I. gravity in order to reduce the viscosity, then chilled to minus 23 deg. fahr. and filtered through heavy filter canvas. The filtrate was cloudy with paraffin wax and on reduction showed a pour test of 45 deg. fahrenheit. Paraffin wax remaining on the filter canvas was sloppy and high in oil content. To another portion of the chilled, wax-bearing solution an amount of filter-aid equivalent to one-fourth lb. per gal. of solution was added, and this mixture filtered on a similar filter cloth. The filtered solution, in this case, was perfectly brilliant and on reduction showed a pour test of 20 deg. fahrenheit. Furthermore, the paraffin wax filter-aid was firm and in such a form that it could be easily washed with additional naphtha to remove surplus oil.

The reason for this is that the oil flows through the channels of the filter-aid particles. The contact with the adsorbent material and the subsequent percolation causes a splitting of the film surrounding the surface of the minute wax particle, resulting in formation of needles and a favorable filtration of the mother liquid through the needle-filter-aid cake. For the purpose of this dewaxing process fine-grained sand is also used, but this material acts only by percolation, without the adsorption phenomena. Of course, Fuller's earth, with its developed interior microscopic channels, facilitates the formation of needles from the amorphous or platy particles of paraffin wax. The reason is that the asphaltic and resin-like substances, as well as the higher molecular hydrocarbons that form the protective films on the surface of the wax particle, are more readily adsorbed by the microscopic channels than are the paraffin wax particles.

Of course, the size of the microscopic channels and the temperature play a very important part in this dewaxing-adsorption process; that is, if the microscopic channels are suitable for the adsorption of certain colloidal or crystalloidal compounds, the use of such filter-aid at the proper temperature increases the adsorption of the above-mentioned inhibitors. Under unfavorable conditions, greater amounts of paraffin wax particles are adsorbed by the interior of the microscopic channels. Under proper adsorption conditions the contact between the wax particle and the adsorbent particle causes the amorphous or platy particles to be transformed into needles. This procedure leads to the production of lubricating oils having a very low pour test.

Dewaxing by means of the adsorption process depends to a high degree upon the filtration velocity. The higher

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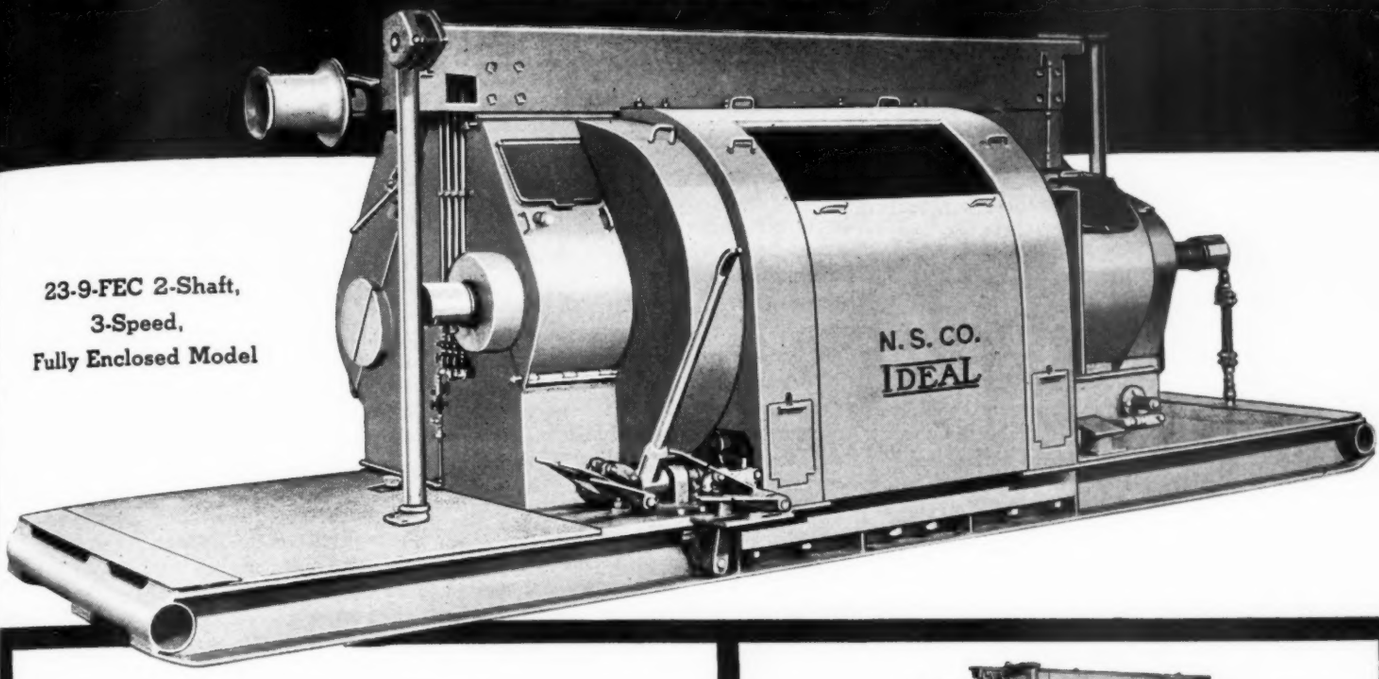

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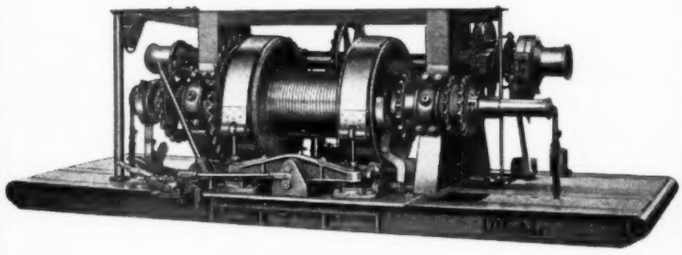

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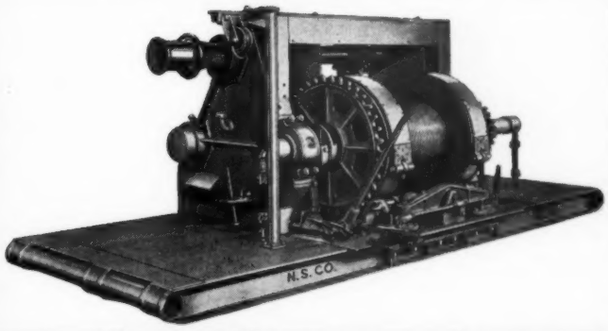

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the velocity, the more the oil will be dewaxed. It has been stated that the filtering velocity depends upon the kind of oil that is to be dewaxed, that is, upon whether the oil is a distillate or a refined product. For example, a highly viscous oil as a distillate is more readily dewaxed by means of the filter-aid than it would be if refined before being subjected to this process.

This phenomenon may be explained by the fact that during the adsorption process the adsorbent material transforms the paraffin wax plates in the refined oil into another form of plates, which, being shorter and smaller, clog the tops of the microscopic channels, resulting in bed-filtration of the oil. This type of crystallization can be classified as intermediate between the platy and the amorphous form of paraffin wax. This has been shown by microscopic investigations by the writer. According to the writer, this type of plates is caused by the movement of the oil particles in the sphere of action of the adsorbent surface. Here the direction of movement is such that the long plates are broken into half plates, these broken plates clogging the tops of the microscopic channels. On the other hand, when the paraffin waxes in the highly viscous distillate come in contact with the filter-aid, the action of the adsorbent surface causes a quite different movement, this movement causing a lengthwise splitting of the plates, causing the formation of several needles from a plate. When an oil containing amorphous paraffin wax comes in contact with an adsorbent material, the recrystallization into needles is more nearly complete than when the paraffin wax particles are present in the form of plates. The reason for this seems to be that the adsorption surface causes the amorphous wax particles to grow into needles. (Fig. 1.) As stated, the needles obtained from the amorphous wax particles are more readily filtrable from the mother liquid than those obtained from the platy wax particles. It is easy to understand why these differences exist. In comparing

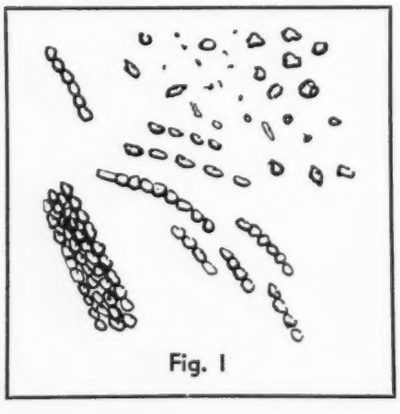


Fig. 1

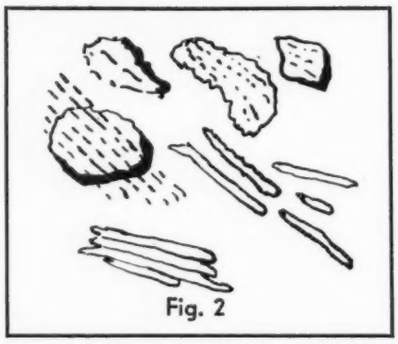


Fig. 2

Fig. 2, which shows the splitting of the plates into needles, with Fig. 1, it can be seen that when the needles form from the amorphous wax particles and lie one upon another, several open places are formed through which the filtrate flows, whereas when the needles form from the platy wax particles and lie one upon another no open place is formed.

In general, the adsorbent material is added as soon as the proper temperature is reached and the chief mass of the original paraffin-wax particles is deposited from the mother liquid. It has been shown by investigations of the writer that the recrystallization of the wax particles by means of the adsorbent material begins at the initial phase of the deposition of the original wax particles from the mother liquid. In this phase the adsorbent surface has a tendency to act on the wax particles as a center of recrystallization.

The deposition of the wax particles from the mother liquid begins at a temperature of about 50 deg. centigrade; however, the contact between the adsorbent surface and the wax particle does not cause a complete recrystallization of the original wax particles into needles at the above-mentioned temperature. The reason for this is that the higher temperatures do not permit complete deposition of the original wax particles from the mother liquid. When the adsorbent is in contact with the incompletely developed original wax particles, these incompletely developed crystals clog the openings of the microscopic and ultramicroscopic channels of the adsorbent material, destroying the recrystallization-adsorption power.

In addition, the filtration of the wax crystals, in this case, causes great trouble in the working process. Such a working process causes a decrease of the filtering velocity. This has been shown experimentally. When adding a Fuller's earth at the temperature of minus 30 deg. cent. to an oil, a filtering surface of one sq. meter gives 25 liters of filtrate in 30 minutes, whereas when the same adsorbent material is added to the same oil at a temperature of 50 deg. cent., one sq. meter of filtering surface yields only 15 liters in the same time. This phenomenon can be explained as follows: the adsorbent material in the dewaxing process not only causes the recrystallization of the paraffin wax particles, but it also acts as a drainage in the filter cake.

Therefore, when the adsorbent material is added to the oil at a temperature of about 50 deg. cent. and then chilled, the incompletely-developed wax particles clog the channels in the filter cake. This clogging stops the drainage, resulting in a decrease of the filtering velocity. This causes not only slower filtration, but also a re-dissolving of certain paraffin wax particles in the filtrate.

It is seen from the foregoing that the use of an unsuitable temperature in the dewaxing process leads to bed-crystallization of the original wax particles, and to the enrichment of the filtrate with paraffin wax particles during its passage through the filter cake. Of course, these two disadvantages cause unfavorable yields.

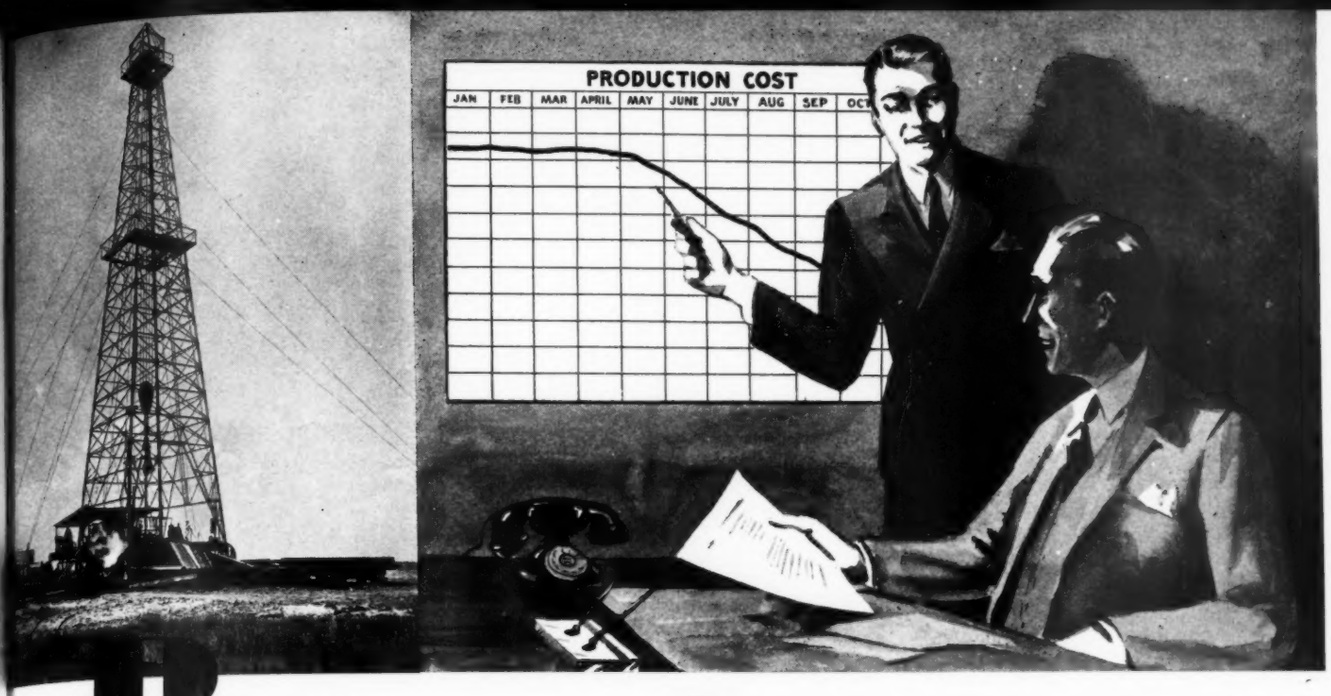
Let us now consider the influence of the temperature on the speed of filtration. When using a cylinder stock having a viscosity of 3.6 deg. Engler at 100 deg. cent. the filtering velocities between the temperatures minus 17 and minus 30 deg. cent. are approximately equal. Table 1 shows the filtering velocities between the temperatures minus 17 and minus 30 deg. centigrade.

Table 1

—17 cent.	27.5 liter per minute
—20 cent.	27.8 liter per minute
—22 cent.	28.1 liter per minute
—24 cent.	28.3 liter per minute
—26 cent.	28.5 liter per minute
—28 cent.	29.1 liter per minute
—30 cent.	29.5 liter per minute

Viewing this dewaxing process in the light of the above, we are forced to conclude that the most important factors influencing the separation of paraffin wax from the mother liquid are: the state of the paraffin-wax particles in the mother liquid, the viscosity of the mother liquid, the viscosity at different temperatures, and the temperature at which the clay and the oil are mixed.

For dewaxing by means of the filter-aid, two types of plants are used. One is a continuous vacuum filter plant that is very simple, compact, and almost automatic in operation. The other is a pressure-filter plant and, although somewhat more equipment is involved, it is more flexible. In both plants the wax-bearing oil is first mixed with naphtha. The end point of the naphtha should not exceed 350 deg. fahr., and it should be of relatively low viscosity.



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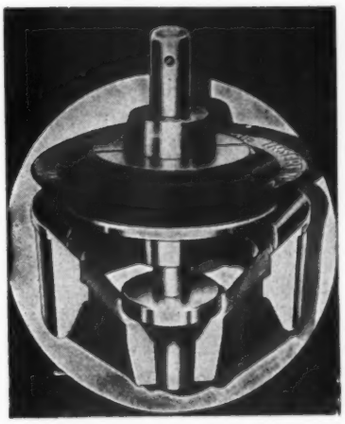

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If the oil has been previouslv processed, e.g., clay-contacted, in a diluted state, the treated solution can be delivered to the filter-aid dewaxing plant and more naphtha can be added if needed. Otherwise the raw wax-bearing oil and the solvent naphtha are pumped by separate pumps proportioned and controlled by flow meters, to a solution tank, where the mixture is heated to dissolve all paraffin-wax particles.

The amount of naphtha used depends on the viscosity of the charging stock. A constant solution-viscosity is maintained on practically all stocks, regardless of stock viscosity, in order to maintain an optimum rate of flow through the filters. This amount of naphtha may vary from 45 percent of the solution for low-viscosity oils to 70 percent of the solution for very high-viscosity stock. The average stock dewaxed is usually "cut" about 60 percent.

From the solution tank, a solution pump forces the liquid through heat exchangers and chillers. When the wax-bearing solution has been chilled and the desired amount of wax precipitated, it flows to the mixing tank, into which the filter-aid falls directly from the recovery system. The re-conditioned filter-aid coming from the recovery system is warm and the wax-bearing solution must be chilled to a lower temperature than the desired filtering temperature to compensate for the consequent rise in temperature. The magnitude of this change will, of course, vary with the filter-aid concentration and the naphtha content of the filter-aid, but the usual increase is 7 to 12 deg. fahrenheit.

Only a short time is required for intimate mixing of the filter-aid with the chilled wax-bearing solution, this being accomplished by paddles in an insulated or jacketed mixing tank. The cold slurry of wax and filter-aid flows directly from this tank to the filter, in the case of vacuum filters, or to the pumps in case of pressure filters. The continuous vacuum filters are either the drum or vertical disk type. The filter elements move continuously through the mixture to be filtered. While the filter elements are immersed in the cold mixture the oil is drawn through the filter medium and a cake or layer of wax and filter-aid is deposited on the surface of the filter medium.

The filter medium continues to revolve, rising from the mixture into a drying area where cold gas is pulled through the filter cake and the surplus oil-solution drawn out by gas displacement. After the cake is dried it continues to revolve to a discharge point where a slight back-pressure of gas on the inside of the filter element distends the filter medium and discharges the cake over a discharge scraper. The clean filter medium then continues to revolve and is re-immersed in the cold mixture in the bowl of the filter. In this manner the un-dewaxed oil passes to the filter and the dewaxed oil flows from the filter continuously.

In the pressure filter system the cold wax-filter-aid mixture is pumped by a triplex pump to the pressure filter, which is enclosed in an insulated cold room maintained at a low temperature by ammonia coils. Vertical filter disks are used in the pressure filter, each disk being composed of separate filtering sectors mounted on a rotating shaft. The pressure charge-pump forces the oil solution through the filter sectors, depositing on their cloth covers a layer of wax and filter-aid. Pressure is gradually increased until 150 lb. per sq. in. is reached and the pressure is maintained until a filter cake about one inch thick is formed. The wax-filter-aid cake formed on the filter cloth is washed with additional cold solvent when necessary to improve yields, dried with cold inert gas, and discharged to a mechanically-agitated slurry tank. Weak wax solution coming from a wash receiver at the filter-aid recovery tank is added to the wax-filter-aid cake in the slurry tank to form a pumpable slurry. This slurry is then heated to about 150 deg. fahr. to dissolve all wax and is pumped to the filter-aid recovery tank situated above the mixing tank and cold-filtered.

These considerations indicate that the amorphous and platy wax particles, which cause great trouble in the conventional methods of dewaxing, can be easily transformed into filtrable needle crystals. This re-crystallization is caused by the adsorption process of the microscopic channels. It can be now seen that the microscopic channels are able not only to adsorb the impurities from the petroleum products and to fractionate oils, but also are able to transform difficultly filtrable wax particles into needle crystals.

Study of Oil-Meter Calibration Made by Bureau of Mines

POSITIVE-DISPLACEMENT oil meters can be used to measure crude oil flowing in pipes in the field and elsewhere, provided the counting mechanism is in proper adjustment and the oil has been studied sufficiently to determine the proper correction factor to be applied to the meter reading to adjust for the shrinkage of oil caused by the liberation of gas from solution, states the U. S. Bureau of Mines, which has completed a study on oil-meter calibration. A report giving the results of this study was made public at the Oil-Metering Conference, Norman, Oklahoma, April 7.

Two different types of calibration tests were made. The first was a direct calibration to determine the accuracy of four different meters, through which measured quantities of weathered oil were pumped at different rates of throughput. The second type of test was made to determine the magnitude of error when metering a gas-saturated oil in which a pressure drop was induced upstream from the meter purposely to cause liberation of gas from solution in the oil in order to study the probable error under those conditions. The gas-saturated oil was obtained from a flowing well in the Oklahoma City field. The operating pressure in the separator was held between 80 and 83 lb. per sq. in. gauge.

In connection with the meter-calibration study with gas-saturated oil, a sample of the oil was taken from the oil-gas separator under the same operating conditions as was the oil used for the meter tests. The oil sample was broken down in the laboratory into its proportionate parts of gas and oil at lower pressures. The quantity of gas liberated from solution and the shrinkage of the oil due to the liberation of gas were determined for each pressure reduction between the operating pressure of the separator and atmospheric pressure.

The results of the meter tests with gas-saturated oil in which pressure drops occurred upstream from the meter showed that the error in volume measurements by the meter was large. This error is proportional to the amount of gas liberated from solution at the reduced pressure, or, on the other hand, the gas actually may cause the same volume displacement in the meter as an equal volume of liquid.

The results of the oil meter-calibration tests, as well as sketches of the equipment used for both types of calibration, are presented in a Bureau of Mines Report of Investigations, "Calibration of Positive-Displacement Oil Meters," by R. E. Heithecker and W. B. Berwald, soon to be published cooperatively with the State of Oklahoma. When issued, the report will be obtainable upon request from the Bureau of Mines, Washington, D. C.

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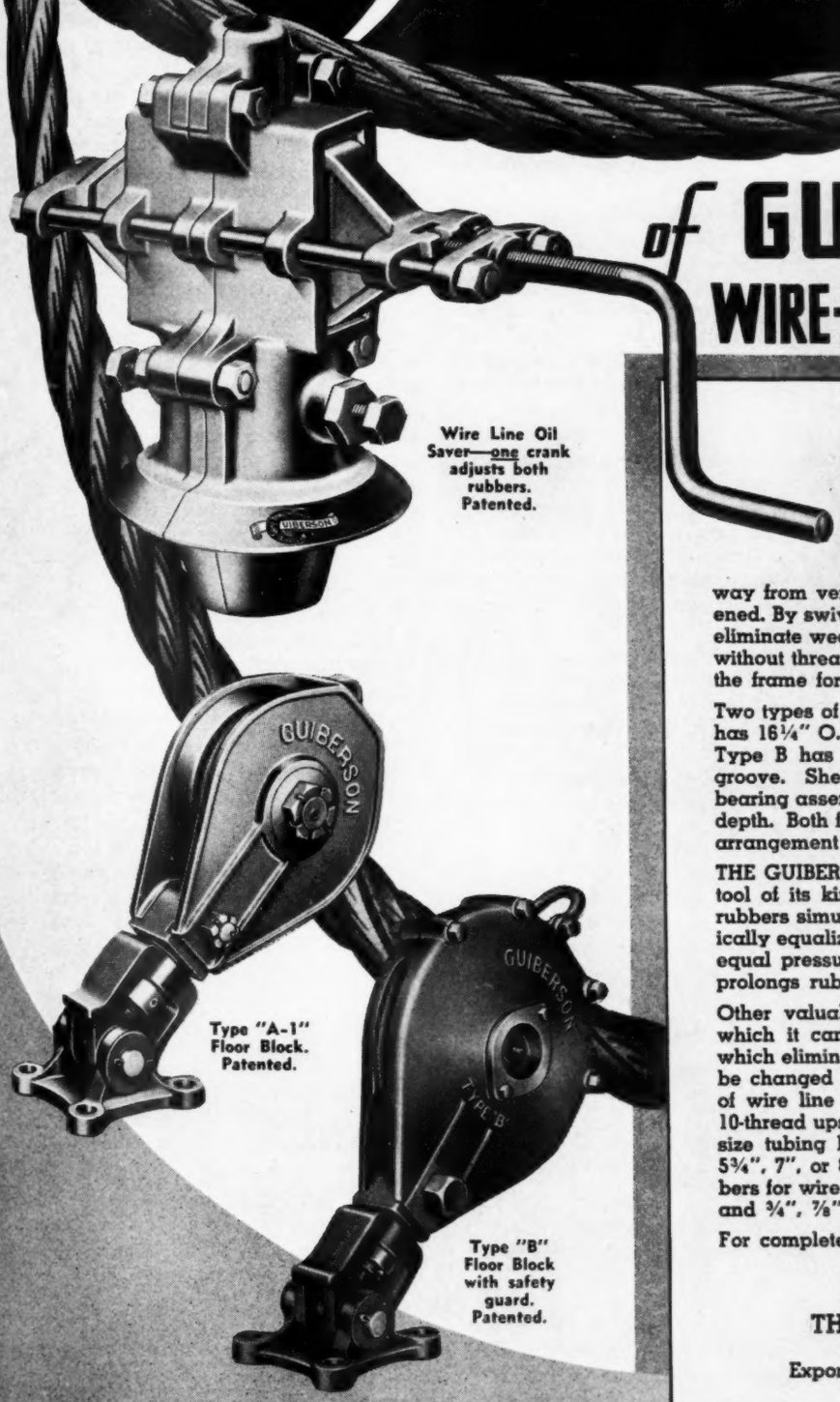

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Tracing Diesel Oil Pollution

By CHARLES C. LYNDE

AFTER less than two years' service in a main line crude oil pumping station, three 400-hp. Diesel engines suddenly began to show an abnormally high water content in the lubricating oil. From a mere trace, the water content suddenly increased to 0.025 percent, and some of the samples after centrifuging showed as much as four percent water. The emulsion was so tight it would not break down after whirling for the specified ten minutes at the standard speed of 1500 revolutions per minute.

Immediately the engineer in charge of the reclaimer noticed that the oil could not be cleaned in the specified time, and that it was necessary to operate the reclaimer at top speed practically throughout the entire shift to obtain a sufficient supply of clean, water-free oil. It was also noted that the sump stock was rapidly broken down by the excess water, and that the quantity of carbon and metallic particles increased rapidly.

Investigation revealed that the excess water in the crankcase was jacket or cooling water, which worked downward between the block casting and the cylinder liner, escaping through the pack-off or seal ring.

As quickly as possible, each of the units was stopped and the cylinder liners were pulled to permit installation of new rings—this being done although a most exacting inspection of the liners when pulled failed to show any serious break-down of the packing rings despite the evidence of water flow.

Even before the pipe-line runs could be scheduled to permit the third unit to be overhauled, water again appeared in the lubricant from engine No. 1. Repetition of the tests showed that this "tramp" water also was engine cooling water.

Checking of the station log revealed that the only variation from routine that might have affected the water supply was the renewal of the piping carrying cooling-water from the motor-driven centrifugal pump to the three engines. This work had been done about two weeks before the trouble first was apparent, but it was believed that every necessary check on piping, pump, gauge, and relief valve had been made at that time. The system involved the use of the pump to force the water into the engines, through them, and over the top of the cooling tower, a pressure of 20 lb. per sq. in. being maintained on the pump discharge line and the engine temperatures being maintained at the desired point by pinching the valve on the discharge line from each engine.

As another complete check of the water system was being made, it was observed that the temperature-control valves whistled, indicating that there was a greater pressure than formerly on the line. Again the pump pressure gauge was removed and tested with a dead-weight gauge tester at pressures of 5, 10, 15, and 20 lb., and it registered each pressure well within the allowable variation. Once again installed, it registered the desired 20-lb. pressure when all three units were operating, but failed to go above that mark even when the spring-loaded by-pass valve was tightened almost to the point of maximum pressure of the pump.

Inspection of the segment and pinion of the pressure gauge revealed the trouble. When the gauge was removed at the time of renewal of the cooling-water lines, a small chip had become wedged in the segment, preventing rotation beyond the point where this obstruction met the pinion tooth. Instead of subjecting the packing rings to the specified maximum pressure of 20 lb. per sq. in., inasmuch as the gauge failed to function above that point the by-pass valve had been adjusted to require 70 lb. to operate, and the engine jackets and the pliable packing rings were being subjected to this excess load simply because the gauge could not indicate any pressure above the amount specified, regardless of actual pressure provided by the pump.

As a result of the trouble experienced, the cooling-water system was remodeled to provide gravity flow from an elevated tank through the Diesel engines, the hot run-off water being piped to a sump and thence lifted by a pump to the top of the cooling tower, a similar float-actuated pump serving to lift the water from the base of the tower to the gravity tank.

This pipe line company now specifies dead-weight testing of all gauges to twice their normal operating range or to the scale limit after each removal of the gauge from its working position.

Pioneering, 1938 Model

Oil drillers in the South American jungle have been indulging in the pioneer pastime of dodging Indian arrows. Wherever the search for petroleum may lead, pioneering usually is necessary. In the tropics, however, pioneer oil workers have run into peril with a capital P—and have been ingenious enough to devise a clever plan for self-protection.

In Venezuela, where American companies are aiding the development of rich oil reserves, there lives a tribe of Indians whose members still resent the invasion of their happy hunting grounds by the white men who followed Christopher Columbus.

These Indians, known as the Motilones, apparently have resisted all efforts at pacification, remaining as warlike as the redskins of North America's prairies. Consequently, their welcome to the oil-workers in the Guajeras region—their own particular domain—has been one of fierce resentment, taking the form of jagged arrows, hurled with an accurate and deadly aim.

Things began to look serious for the oil men. But not for long. A radio request to headquarters in Caracas brought a fast shipment of coats of mail, similar to those worn by the knights of medieval Europe. The "iron jerseys" weigh five pounds apiece and are anything but cool under the torrid rays of the tropical sun. However, they have proved to be dependable protection against Motilone arrows. Not one casualty has been reported since their receipt, and oil development in the Guajeras is proceeding on schedule.

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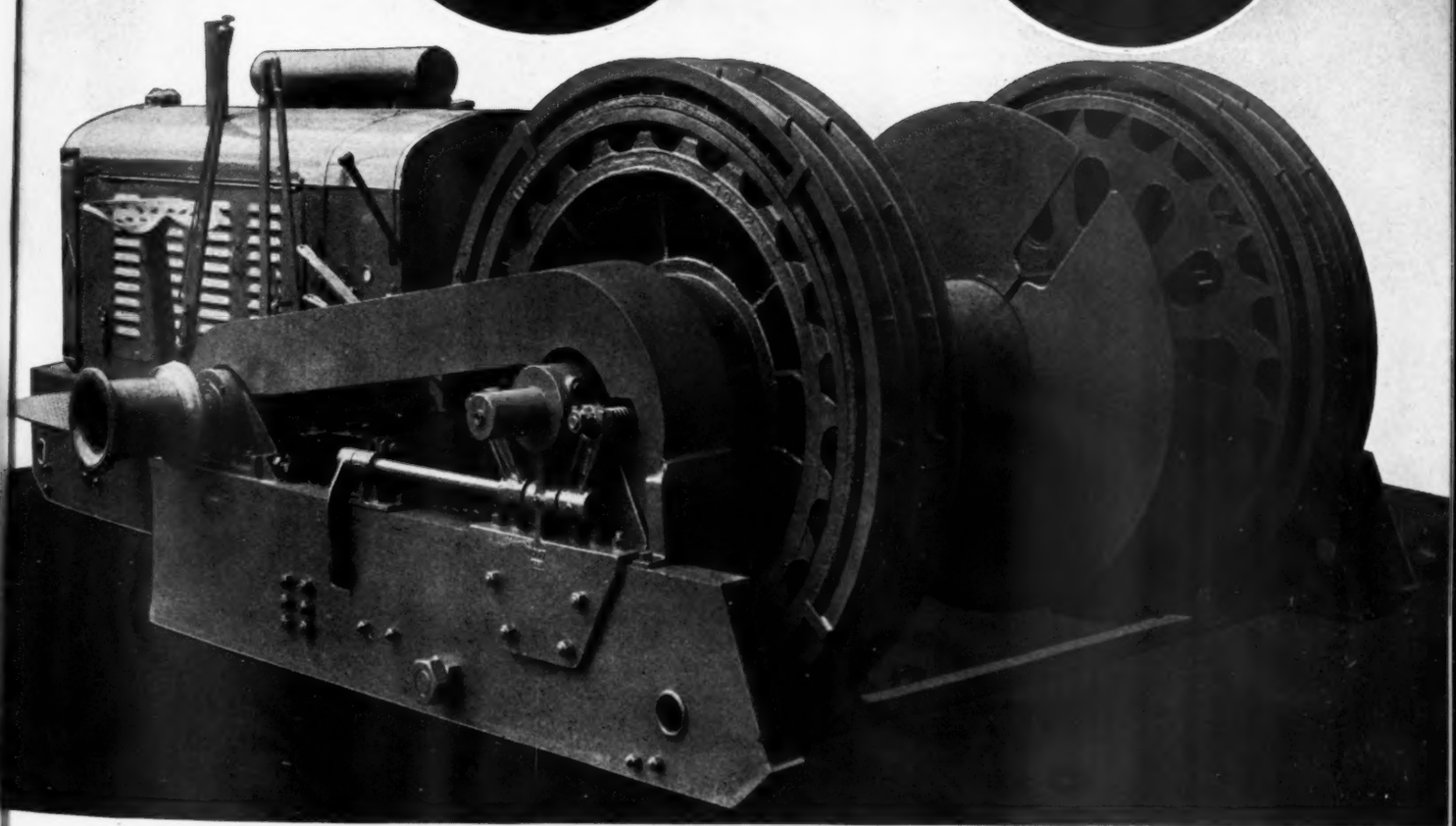
Six cylinder engine. 5¼" bore, 6½" stroke. 844 cu. in. displacement. 550 ft. lbs., torque at 700 r.p.m.

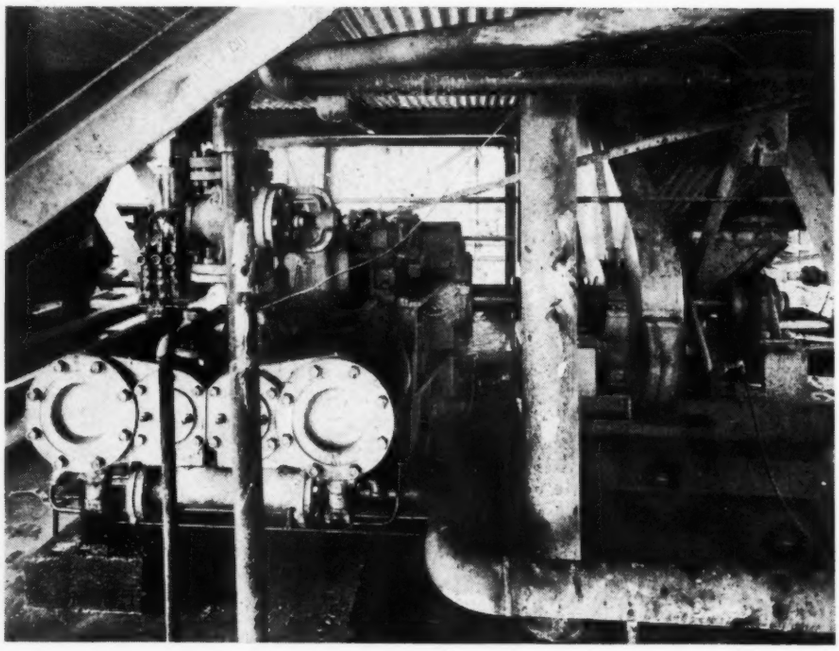
Maximum line pull 62,000 lbs. Eight line speeds from 66.6′ p.m. to 1107′ p.m. Line capacities 39,300′ of ½", 13,600′ of ⅞".

Large capacity water system. Full force feed lubrication.

Transmission designed and built for extra heavy duty drilling service, *not automotive type.*

Available as skid unit for truck mounting or as self propelled unit.





The underfloor drive on Superior Oil Company's No. 1 Wagner, Rio Bravo field, California

(Photo Courtesy National Supply Company)

By

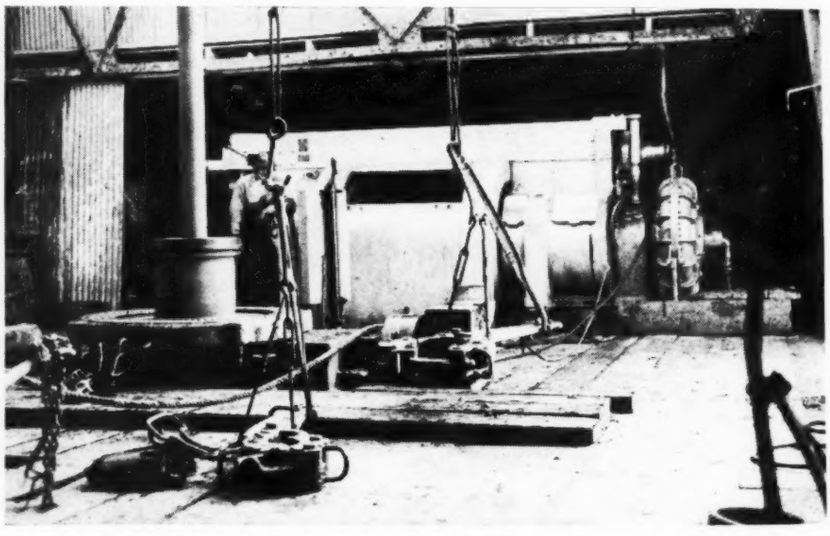
Wallace A. Sawdon

Petroleum Engineer, Los Angeles

Some wells in the Rio Bravo field are being drilled to depths exceeding 11,000 ft. in a total elapsed time of less than three months

Modern Equipment Facilitates Deep Drilling in California » » »

THE use of comparatively light equipment in drilling wildcat wells to great depths in California has been due mainly to the fact that generally the original intention was to penetrate to depths far less than those finally drilled. The Continental well drilled to 15,004 ft.[1] was expected to stop before reaching a depth of 10,000 ft. and the Union Oil Company's discovery well in the Rio Bravo field was planned to reach a depth of about 9000 feet. Such wells must be drilled with extreme care and drilling rate is reduced not only by the equipment used but also by the necessity for extensive coring. On wells subsequently drilled in the development of a field the most modern equipment generally is employed and full advantage taken of the increased drilling speed and other economies that are provided by such equipment and enhanced by the knowledge of formations as provided by the first well.



Note the space and convenience on the derrick floor, as well as the safety features of the enclosed drawworks, on this well being drilled with underfloor rotary drive

In the Rio Bravo field in the San Joaquin Valley, California, wells are rigged up with the knowledge that production will be obtained at a depth below 11,000 ft.—the deepest in the world until the recent completion of the Continental well, in which the oil sand is below 13,000 feet. Despite the great depth, the use of most modern equipment has resulted in exceptionally fast drilling time, striking evidence of which are the two wells completed by Superior Oil Company since the discovery well was drilled. One was completed at a depth of 11,240 ft. in 87 days and the other at 11,238 ft. in 85 days. Union Oil Company's second well is being drilled using the rig employed in drilling the discovery well but its third well will be drilled using equipment very similar to that to be described presently.

In considering the speed made at Rio Bravo there is no doubt that the modern equipment used contributed to the rapid completion and was thus an economic factor in the operation.

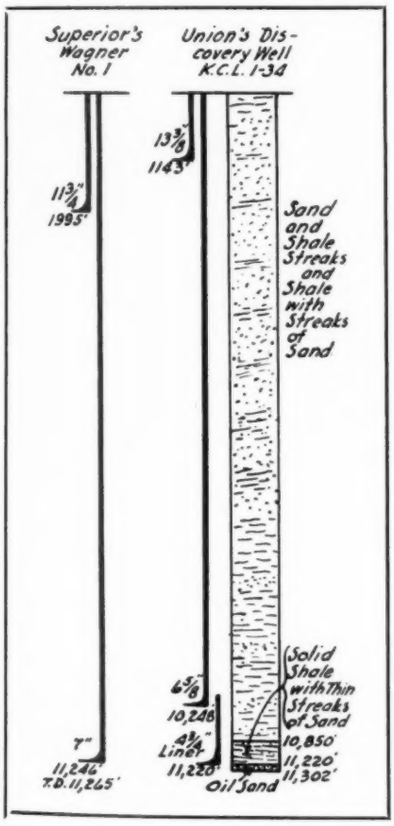
[1] *The Petroleum Engineer*, April, 1938, pp. 58-60.

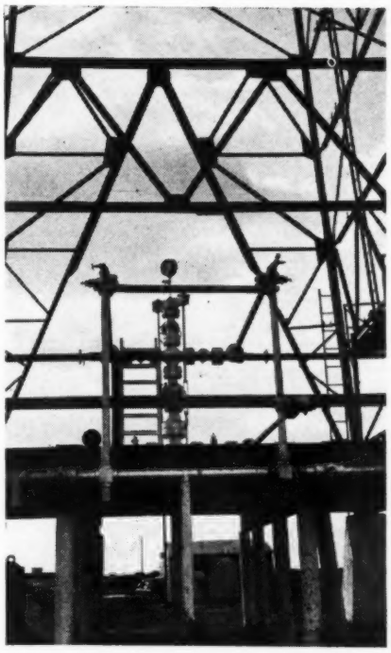
Drilling conditions, however, are favorable and, as shown in Fig. 1, open hole can be carried 10,000 ft. below the surface casing. In the discovery well a liner was set in the water string and cemented at the top of the sand, but the well was brought in "barefoot." An aluminum liner was used because it might have to be drilled-up if the well had to be deepened. The general casing program at Rio Bravo, however, consists of only two strings of casing. The surface string is usually 13⅜-in. and is cemented at a depth of 2000 feet. Open hole is then carried to the top of the sand and 7-in. casing cemented as a water string.

The wells are kept straight by controlled vertical drilling. Inclination readings are taken at frequent intervals and in the discovery well the inclination at 10,000 ft. was 2¼ degrees.

High rotating speeds have gained favor in California and, inasmuch as wells can be kept straight by coördinating the weight carried on the bit with the rotating speed to give the best results in different formations, the drilling speed attained by proper drilling control has proved to be of economic value. Wear and tear on equipment caused by fast rotation has been eliminated by the installation of individual rotary table drives using both steam engine and electric motor power. These drives have demonstrated their value in various California fields. Most installations heretofore have been placed on the derrick floor.

Fig. 1. Showing formations drilled at Rio Bravo, California, and the casing records of the discovery well and the second well completed. More than 10,000 ft. of open hole was drilled below the water string in both wells





The production hook-up on the Union Oil Company's discovery well in the Rio Bravo field

In drilling the two Superior Oil Company wells, which are the only wells except the discovery well that have been completed at the time of writing, the underfloor rotary drive was operated at rotating speeds of 300 to 350 revolutions per minute. The elevation and plan of this underfloor rotary drive is shown in Fig. 2 and illustrated by the accompanying photographs, which were taken on Superior's Wagner No. 1 well. The drive is independent of the drawworks and is powered by a 9-in. by 8-in. twin steam engine placed below the derrick floor. The emergency drive to the drawworks (shown in Fig. 2) will be utilized on the third Union Oil Company well to eliminate the standby hoist, because, rotation and circulation being provided by separate units, it is thought that any shut-down of the drawworks or its engine will not endanger the operation.

The rotary-drive engine, situated below the floor, is direct-connected to an extension shaft by a flexible coupling. The engine is mounted on a skid base, which is bolted to another base having two pedestals that carry the extension shaft. The extension shaft carries two clutch sprockets, one for direct drive to the rotary table and the other for the emergency drive to the drawworks through a countershaft. The chain drive is fully enclosed and runs in an oil bath. A control stand for operation of both the engine throttle and power reverse is situated at the driller's position on the derrick floor. The engine throttle is operated by a hand wheel through a light chain drive, enclosed in the control stand, and a torque rod. The power reverse is controlled by a foot pedal at the base of the stand.

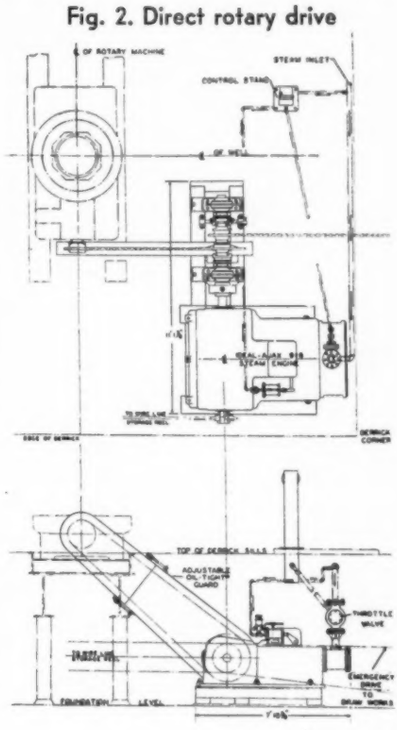
The features of the underfloor drive include greater safety because of clear floor space around the rotary table, as indicated by the accompanying photographs, and less noise and vibration while drilling. The elimination of wear and tear on the drawworks and hoisting engine has been clearly demonstrated by individual rotary drives, which also permit work on the drawworks and its engine while drilling. Fuel economy has also been found to accompany the use of rotary drives; and, using the underfloor installation, the emergency drive can serve as a standby unit.

The drawworks on the well illustrated is a 2-shaft-plus-cathead-shaft, three-speed type, exerting a line pull of 56,900 lb. at low speed. It is fully enclosed and is driven by a 14-in. by 14-in. twin steam engine. The standby hoist is an old drawworks powered by a 12-in. by 12-in. twin steam engine.

The cellar hook-up on Wagner No. 1 as shown in the photograph included two cellar control gates with remote control. Mud circulation was provided by two 15½ by 8½ by 20 steam slush

(Continued on Page 62)

Fig. 2. Direct rotary drive



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OIL WELL SURVEYING. Designed to meet every well condition encountered in drilling or in completed wells in either open or cased holes.

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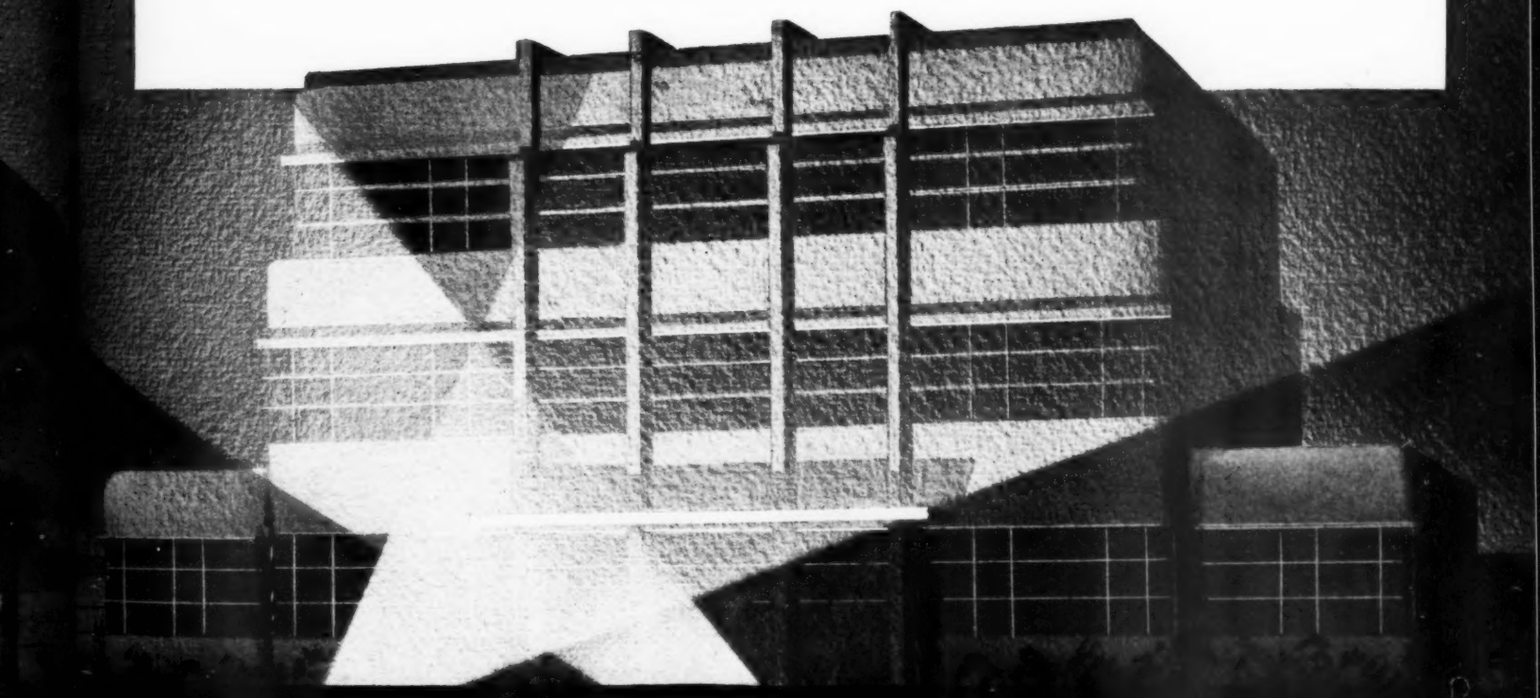
CARRYING STRAIGHT AHEAD A PLEDGED POLICY OF COMPLETE OIL FIELD SERVICE

Effective immediately, Lane-Wells Company is announcing to the Oil Industry of the United States full details in connection with its new electrical open hole logging service. This service, fully covered and protected by patents issued and others pending, is the result of Lane-Wells' negotiation and licensing agreements worked out on an international scope.

Six years ago when this organization entered the Oil Industry with a new service,—gun perforating,—it pledged itself, through the application of skillful engineering, scientific design and research, to develop as complete and reliable services as might be devised. To that end the entire Lane-Wells organization has labored until, today, it sees the fulfillment of plans which, when first advanced, were regarded as impossible.

Lane-Wells does not intend to rest upon its laurels. It will continue to push forward, aided by study, research and engineering design with one thought in mind—always better service to the Oil Industry.



TECHNICAL OIL FIELD SERVICES

(Continued from Page 59)

pumps and the mud was conditioned through two vibrating screens. A separate 14 by 7½ by 14 pump was used for mixing and handling the weight material that was introduced into the mud stream as needed.

The boiler plants serving the Superior wells consist of a battery of four boilers so situated that the one setting can be used while drilling four locations. The boilers have integral superheaters and the rating of each boiler is 125 hp., 350-lb. working steam pressure. No dome is used because the steam storage space in the shell above normal water level is made adequate without the dome.

There is considerable variation in the weight of mud used by different companies drilling at Rio Bravo. Union Oil Company uses probably the lightest mud and in straight drilling maintains the weight at about 78 lb. per cu. foot. Union has done extensive research on mud control and gives the fluid constant attention. A 78-lb. mud gives a hydrostatic pressure exceeding 6000 lb. per sq. in. at 11,300 ft. and is ample for control providing the mud is kept in proper condition. By properly conditioning the mud fluid, better hole is drilled and better protection is given to the face of the sand by the formation of a plaster that prevents infiltration of water while drilling but is easily removed when the well is to be completed.

The wells at Rio Bravo are being produced through chokes. The Union discovery well is restricted to approximately 450 bbl. per day through a 3/64-in. bean, which may, perhaps, be somewhat worn. This well had an initial flow of 2400 bbl. per day through a 40/64-in. bean. A production test through a 20/64-in. bean gave 1666 bbl. at a pressure of 2149 lb. on the casing and 2175 lb. on the tubing. The gas/oil ratio of present choked production is approximately 1400 cu. ft. per bbl.; the gravity of the oil is 40 deg. A.P.I.

Superior Oil Company's No. 1 Wagner was drilled only 18 ft. into the sand to a depth of 11,265 ft. but had an initial production of 800 bbl. per day through a 9/64-in. bean, at a casing pressure of 2100 lb. and tubing pressure of 2075 pounds. Present production from this well is restricted to less than 600 barrels.

Superior's second well, No. 1 Gussinger, was drilled about 50 ft. into the sand to a total depth of 11,288 feet. Its initial production was 1100 bbl. of oil and more than 1,000,000 cu. ft. of gas through a 15/64-in. bean.

Two more wells are in the sand at the time of writing and probably will be completed by the time this goes to press. Both, however, reached the sand at depths about the same as those of the wells already drilled. One well is being drilled about a mile southeast of the present producing wells and is reported to have found markers appreciably lower structurally than did the wells offsetting the discovery well. The limits of the field have not been defined.

Bureau of Mines Analyses of Pennsylvania and New York Crude Oils

PETROLEUM produced from different oil fields in the states of Pennsylvania and New York is similar in character and uniform in quality, according to a survey by the U. S. Bureau of Mines. This similarity exists regardless of geographical distribution of the fields, depth of wells, date of collection of the samples, or method by which the oil was produced. Samples were taken from properties where no secondary recovery practices have been employed as well as from properties where water-flooding and repressuring were used. Samples of oil from fields in Venango County, Pennsylvania, appear to have lower gasoline content than the others.

The Bureau has collected and analyzed samples of crude oil from oil fields of Pennsylvania and New York during the last 19 years, the first sample having been taken in February, 1919. All the samples were analyzed by the Bureau of Mines Hempel method, which is described in Bureau of Mines Bulletin 207, The Analytical Distillation of Petroleum and Its Products, by E. W. Dean and others. The method provides close and accurate control of the laboratory distillation, and, because it has been standard procedure in the Bureau's laboratories since 1919, analyses made by this method today are comparable directly with those of earlier dates.

Details of this survey are being prepared for early publication as a report of investigation that will include analyses of 58 crude oil samples collected within the Pennsylvania-New York area. Copies will be available upon request to the Information Division, Bureau of Mines, Washington, D. C.

The analysis of a sample from a well producing from the Bradford Third Sand, Bradford Field, McKean County, Pennsylvania, which is representative of the Pennsylvania and New York oils, gave the following data:

BUREAU OF MINES HEMPEL ANALYSIS OF A TYPICAL SAMPLE OF PENNSYLVANIA CRUDE PETROLEUM

Hawkins Bryner well 1-C-1 — Bradford Field — Pennsylvania
1816-49 feet — Bradford Third Sand — McKean County
Petroleum Reclamation Co.

GENERAL CHARACTERISTICS

Specific gravity, 0.800 — A.P.I. gravity, 45 deg.
Sulphur, p rcent, 0.11 — Color, green
Saybolt Universal viscosity at 100 deg. fahr., 39 sec.

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Dry distillation — Barometer 738 mm. — First drop: 32 deg. cent. (90 deg. fahr.)

Temperature, deg. cent.	Per-cent cut	Sum, per-cent	Specific gravity of cut	A.P.I. gravity of cut	Viscosity at 100 deg. fahr.	Cloud test deg. fahr.	Temperature, deg. fahr.
Up to 50	2.1	2.1	0.650	86.2			Up to 122
50— 75	4.1	6.2	.664	81.6			122—167
75—100	5.0	11.2	.693	72.7			167—212
100—125	6.7	17.9	.728	62.9			212—257
125—150	5.9	23.8	.749	57.4			257—302
150—175	5.7	29.5	.764	53.7			302—347
175—200	4.7	34.2	.774	51.3			347—392
200—225	5.7	39.9	.786	48.5			392—437
225—250	5.4	45.3	.798	45.8			437—482
250—275	5.9	51.2	.811	43.0			482—527
Vacuum distillation at 40 mm.							
Up to 200	4.1	4.1	0.835	38.0	41	30	Up to 392
200—225	4.9	9.0	.837	37.6	45	40	392—437
225—250	5.7	14.7	.850	35.0	54	65	437—482
250—275	4.4	19.1	.868	31.5	75	75	482—527
275—300	6.4	25.5	.874	30.4	115	90	527—572

Carbon residue of residuum 1.9 percent; carbon residue of crude 0.4 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	Deg. A.P.I.	Viscosity
Light gasoline	11.2	0.674	78.4	
Total gasoline and naphtha	34.2	0.726	63.4	
Kerosene distillate	17.0	.798	45.8	
Gas oil	9.6	.839	37.2	
Nonviscous lubricating distillate	10.7	.844-.872	36.2-30.8	50-100
Medium lubricating distillate	5.2	.872-.877	30.8-29.9	100-200
Viscous lubricating distillate				Above 200
Residuum	21.3	.895	26.6	
Distillation loss	2.0			

Slighted Elements of Well-Pumping Problems

A thought-provoking critical discussion of the possibilities of reducing positive work by increasing negative work in the pumping of wells

By ALEXANDER B. MORRIS
Petroleum Engineer, Tulsa, Oklahoma

MOST discussions of pumping problems and the forces involved are concerned with the stress as measured in the polished rod, which is a resultant of all the individual forces. This article will analyze this resultant into its component parts with the object of determining the nature of each component and its source, rather than its mathematical value.

All the forces and relations developed herein are capable of mathematical presentation. In fact, it was the writer's first idea to set forth a mathematical analysis of the problem, but the notation required was so long and cumbersome, and the expressions developed so formidable-looking, that, had the problem been presented in that form, (1) scarcely anyone would have bothered to read it; (2) very few of those who read it would pay it the slightest heed; and (3) the remaining few would have too many points of difference of opinion. Moreover, a qualitative rather than a quantitative result was desired, so there was little point in bothering with pages of algebra. Anyone interested can concoct this for himself from the following discussion, and if the means for accurate measurement are available, can arrive at a strictly quantitative result.

If an oil well were straight and vertical, the standing valve operated at 100 percent efficiency, and the rods were inextensible, the plunger travel would always equal the polished rod travel, and the stresses in polished rod and valve rod would be composed of the following elements:

On the Upstroke:

Polished Rod:
- Weight of rods
- Weight of fluid column
- Acceleration in rods caused by pumping device
- Fluid friction
- Plunger friction. All positive in sign.

Valve Rod:
- Same, *less* only effective weight of rods, as affected by acceleration.

On the Downstroke:

Polished Rod:

Weight of rods . . .	Positive
Acceleration in rods . .	Negative
Fluid friction	Negative
Plunger friction . . .	Negative

Valve Rod:
- Plunger friction only—Negative. (Valve rod in compression.)

Wells are seldom either straight or vertical, however. If straight, but inclined from the vertical at an angle A, the following additional resistance to rod motion appears: the co-efficient of friction between rods and tubing times the weight of the rods times sine A.

In the polished rod, this quantity is positive on the upstroke and negative on the downstroke. The valve rod is unaffected by it.

But wells are seldom straight throughout their full depth. Let us suppose that through a part of its traverse the well describes a portion of a true helix with a very large lead angle. Through this part of its course, the rods act as though they were wound around a solid drum, the diameter of which is the diameter of the horizontal projection of that part of the well. Even assuming that the rest of the well is both straight and vertical, there must be two "approach curves" to this helical portion. Each of these curves also acts in the same manner, the rods being drawn hard against the tubing toward the center of curvature of the well, regardless of its position at any point. Now "drum friction" increases very rapidly with the amount of central angle subtended by the "wrap". It is an exponential function of this angle, with the angle in the exponent. Thus if the total central angle of the horizontal projection of the well, plus the central angles of the two approach portions, amounted to 29 deg. in one well and to 116 deg. in another, all other conditions being the same, the drum friction in the second well would be, not four times that in the first, but nearly 19 times as great. This element affects only the polished rod stress and is positive on the upstroke and negative on the downstroke.

It can thus readily be seen that any sinuosity in a well, even if it is within the contract tolerance of deviation from the vertical, can have a very marked effect upon polished rod tension; and as the plunger must, in any event, be pushed into the barrel, it is evident that any tendency toward "seizing" of the rods in the tubing on the downstroke can hinder or prevent the downward movement of the plunger.

Now if the crookedness is near the top of the hole, the weight of the rods below the crooked portion will be great enough to overcome this drum friction and to cause the rods to slip through the tubing. The lower end of the rod string will thus be free to bear its weight upon the valve rod, and to push the plunger into the barrel; but if the crookedness is near the bottom of the well, where the rods are normally in compression on the downstroke, there will be insufficient force to cause slippage, the plunger will not go down, the rods will seize in the curve, and the rod string above the seize-point will "snake" in the tubing until sufficient weight has accumulated to overcome the seize. When slippage occurs, the plunger will move down and the whole string of rods will pass from compression into tension with a snap that imparts a serious impact stress to the string.

If plunger friction is great, curva-

ture of the well close to the pump barrel may give rise to an effect the opposite from drum friction, which we might designate as expansion brake friction. The rods, instead of being drawn against the inside of the curve in the tubing, will be forced against the outside of the curve. Instantaneously, at the transition from expansion brake friction to drum friction, the rods will be out of contact with the tubing, will bear unhindered upon the valve rod, and will cause it to drop downward rapidly until drum friction is established to check it. These forces may alternate, causing intermittent, jumpy motion in the plunger, or even in the entire rod string. Inasmuch as variation in the operating speed changes the acceleration in the polished rod, it changes the effective weight both of the rods and of the fluid column. This will determine, for any particular well with its individual configuration and physical equipment, whether or not seizing will take place.

It is often cause for wonder that two wells, apparently identical in depth, surface and subsurface equipment, character of output, and conditions of operation, will give rod indicator cards of such totally different appearance. One would suppose that with everything as nearly identical as possible in the two wells, similar cards would result. Differences in effective drum friction due to unobserved or unobservable differences in well curvature and its location with respect to the pump barrel could readily account for the variance between the rod cards of two otherwise identical wells. When drum friction increases, the weight of the rods below the curved section of the well is reduced. At the point of seizure it is all removed. When subsequent slippage occurs, this weight is suddenly restored, less, of course, the amount still supported by drum friction. The consistent occurrence on rod cards of points of very low stress at definite points on the downstroke can thus be explained. On the upstroke, seizing will cause otherwise unexplainable peaks in rod stress, which will always occur at the same point in the stroke for any given well and operating speed. With change in equipment or in operating speed these peaks will change position or disappear altogether. Because drum friction is most certainly operative in even a slightly crooked hole and would cause changes in the polished rod stresses similar to those observed, it is reasonable to assume drum friction to be the cause of these otherwise unexplained occurrences.

In all the foregoing, it has been assumed that the rod string was actually inextensible, and that any difference in polished rod and plunger motion was the result of "snaking" of the rods, the building up or taking out of slack in the rods, caused by the tendency to seize in the tubing. But a 6500-ft. string of rods working in 3-in. tubing actually stretches a matter of feet, within the elastic limit of the steel. In a straight, vertical hole this would permit a considerable amount of movement of the polished rod before the plunger moved at all. Consider now, the rods at rest with the plunger down. The polished rod starts upward, and the stress builds up in it in a straight line without movement of the plunger until the elastic pull of the rod-string equals the total load. As the beam approaches and passes the top of its stroke there is very little motion in the polished rod, but the plunger is still rising, and has a considerable distance to go before it moves as far above its low position as the polished rod traveled. Although the polished rod is almost stationary, movement is maintained in the plunger by this elastic pull, but before the plunger can reach the top, the polished rod has already started down, decreasing the tension in the rod-string from the top as the upward movement of the plunger permits it to decrease from the lower end. Thus, even in an ideal well, the plunger cannot travel as far as the polished rod, even at extremely low operating speeds, when time is given for these off-set motions partly to equalize themselves. Because the fluid load is removed from the rods on the downstroke, the plunger travel will never equal the polished rod travel. The amount of this difference can be calculated for any given set of well conditions. When the difference between plunger travel and polished rod travel is known to exceed this calculable amount, the excess measures the degree to which snaking of the rods occurs.

What can be done about all this? A good many things. Rod guides equipped with roller bearings placed on the rod string where it works in a curved part of the well would all but eliminate drum friction and the resulting troublesome peaks and troughs in the rod card. Increasing the weight of the rod string in proportion to that of the fluid column would increase the amount of negative work done upon the pumping device by the falling rods on the downstroke. A suitably designed pumping unit would store this negative work for release on the next upstroke. The net energy expended by the prime mover would be less in proportion to the amount of useful work performed. This same result and some other benefits could be obtained by setting the pump barrel in a packer and actuating the plunger by means of a string of tubing, equipped with tool joints as is drill pipe, through which the fluid would be pumped. Roller guides on such a string of tubing would reduce all forms of well friction to insignificance. All fluid friction would be eliminated on the upstroke and that on the downstroke would be greatly reduced, because of the absence of obstructions to flow in the tubing. There would be no tendency to snake or seize, and the negative work done by the falling heavy string of tubing would nearly equal the positive work done by the prime mover in lifting the tubing full of fluid. Such a pumping system would in effect straighten even very crooked holes.

These ideas are extremely heretical. They appear to deny the validity of a large part of the research work done on pumping problems, and to point in an exactly opposite direction. They seem so, however, only because most of the improvements in pumping have concerned themselves with what happened between the polished rod and the prime mover. Apparently it has been assumed, even in the face of evidence to the contrary, that the weight of the rods was certainly sufficient to cause them to fall and to push the plunger down. As the most popular device for actuating the rods has always been a walking beam, which is ill-adapted to the salvaging of negative work, the possibilities of reducing net power input by increasing the amount of negative work naturally have been neglected. Instead, because negative work cannot be efficiently utilized by present types of equipment, all efforts have been directed to reducing the positive work that the prime mover must do upon the well; hence, tapered rods and, to some extent, tapered tubing, although the latter has other advantages as well. If, instead of assuming that a walking beam is a necessary element of any pumping device, we consider the conditions all the way down the rod string to the standing valve in the pump, it will become evident that, for many wells, other, more suitable actuating devices are available. The utilization of the negative work is the most neglected opportunity for improving methods and equipment for pumping.

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...EWER ROUND-TRIPS OF THE DRILL PIPE

Elliott Wire Line Core Drills cut coring time and costs to minimum by eliminating many round trips of the drill pipe.

With the drill collar assembly on bottom, the inner barrel assembly is dropped in the drill pipe and requires only a few minutes to seat in coring position on bottom in a five or six thousand foot well. When the desired footage of core has been cut, the inner barrel with its core is retrieved on the wire line and another inner barrel dropped in the hole. This procedure is repeated until the cutter head is dulled.

The new Elliott streamlined cutter heads make faster hole, and from 150% to several times more footage than conventional types before losing efficiency. Less replacements of cutter heads and fewer round trips of the drill pipe are required. Oil well coring is thereby reduced to the ultimate in simplicity, efficiency and economy.

Write for Bulletin No. 37-W

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4731 East 52nd Drive, Los Angeles, California, U.S.A.
Export Office: 420 Lexington Avenue, New York City

ELLIOTT Wire Line Retractable CORE DRILL and DRILLING ASSEMBLY

Discovery Wells today

Tents were everywhere and shacks sprang up like mushrooms. Frost oozing out of the ground made Waterways a quagmire; but the place was to be a city, and nothing mattered. Everyone talked of oil. Everyone was happy. Everyone was going to be rich!

The previous winter Wada, Tony Neis, Rankin, George Pinskey, and others, drove their dog teams north in a wild race to stake claims. Then, in March, 1920, Gorman and Fullerton, with two Junkers, headed north for the same purpose. That was the first flight ever undertaken into the Far North.

OIL AT THE ARCTIC

By
THOMAS H. INKSTER

LIQUID gold has the same magnetic attraction as the mystic metal, with the mere whisper of a discovery being capable of luring men from all corners of the globe. Geologists know that oil may be found anywhere; in the desert, in the jungle, or within sight of metropolitan skyscrapers; and so, in 1920, when the financial world began shouting about oil along the Mackenzie River, smack against the Arctic Circle, many of them headed down north to investigate. (In the vernacular of the North, one speaks of going down north —never up north—because the rivers flow northward to the Arctic.)

The mighty Mackenzie, explored by Alexander Mackenzie in 1789, was the main trade route through a vast little-known-about fur-trading country. In that day fur *was* king. Gentlemen adventurers traded rum and rifles for bales of fur, and the ermine could be worn by sovereigns only.

Then, one August day in 1896, George Washington Cormack found gold on Bonanza Creek. A boom like thunder roared out of the Yukon and many treasure seekers, old-timers and tenderfeet, honest men and scoundrels, hurdled the rapids of the Athabasca and Slave rivers, descended the longest river in all Canada, went up the Peel, and hiked over the Divide to the Klondike, which offered fame and fortune. Thereafter, prospectors, ever an inch from a million dollars or a million miles from a dollar, and more often in the latter status, plodded along the creeks and rambled over the hills in the immense Mackenzie basin.

Oil seepage along the Mackenzie had, for some time, been reported by prospectors, isolated trappers, and travelers through the great lone land, when Imperial Oil set out to determine if Old Lucifer's fiery fluid was there in quantity. They sank three wells 50 miles below Fort Norman, and in so doing caused a furore that sent hundreds of men scurrying northward to join in the mad scramble for oil claims. I was one of them. Transportation companies "permitted" their employees to stake claims on a fifty-fifty basis, and I turned steamboat purser, being on the *Northland Echo* the first year, later on the *Northland Trader* of the lower run.

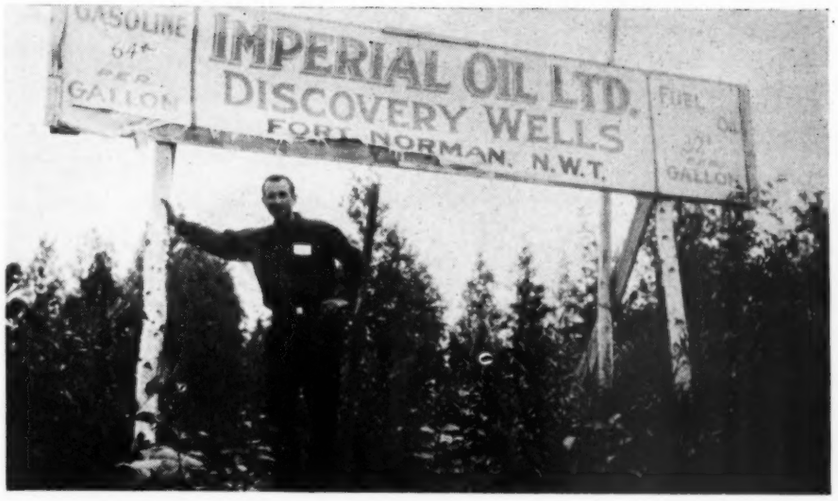
Over the Alberta and Great Waterways Railway, steel casing, drilling equipment, and machinery of every description was rushed 300 miles from Edmonton to the end-of-steel on the Clearwater River. Cars going off the track was a daily occurrence, as the track traversed many miles of muskeg. Teams hauled freight from the cache until the ribbons of steel had been stretched to Waterways, where steel meets keel.

Silver Queen taking a load of oil from Discovery Wells

"Peace River Jim," the perennial humorous and optimistic sourdough, was the most colorful character of that turbulent period. During the Klondike heyday he piloted scows through the rapids—at a profitable figure. A year or two later he brought many of the unfortunate gold seekers back—for nothing! He was a fur trader. Later he built a fleet of steamboats, and had a part in building northern railroads. He took a battalion overseas, and returned Colonel J. K. Cornwall, D.S.O. He is still in the North, still a sourdough, still doing his part to push the frontier into the Arctic Sea.

Pat and Mickey Ryan were two brothers who wandered north from Indiana, and entered the transportation business with one team of horses. Seeing what was ahead, they acquired several teams of horses and moved farther north to the Smith Portage, later replacing the horses with automobiles, trucks, and tractors.

From the end-of-steel, the *Northland Echo* carried equipment and supplies 300 miles down the Clearwater and Athabasca rivers, across Lake Athabasca, and down the Slave River to Fort Fitzgerald. With a stern paddle wheel, like the Mississippi river boats made famous by Mark Twain, the *Northland Echo* burned wood and intermittently puffed dark clouds of smoke from her twin stacks. Barges were pushed ahead because of the ever-changing sandbars. Towed behind they would hit every sandbar or the bank at any sharp turn of the river. In the wheelhouse, the captain and the pilot, who could "read" water, performed



Picture of sign at Discovery Wells taken several years ago

CIRCLE'S RIM » » »

The Far-North held many surprises and experiences for those who followed the "boom" that resulted from the find of oil seepage along the Mackenzie River

gymnastics as they sought to keep their floating caravan in the channel.

Teams hauled freight from Fort Fitzgerald over the 16-mile Smith Portage, built to offset the Slave River rapids that drop 109 ft. in the 16 miles, to the "docks" at Fort Smith, where it was juggled aboard boats operating on the deep water of the lower run.

The *Pioneer*, the first Diesel-powered boat to operate in the North and built specially to handle heavy oil equipment, and the *Northland Trader* transported freight from Fort Smith consigned to the oil field, 900 miles farther north—down the Slave River, across Great Slave Lake, and down the Mackenzie River. Both of these boats were propeller type. The *Pioneer* has since been destroyed by fire, and the wood-burning *Northland Trader* ended her meritorious career when she piled-up on one of the small islands of Great Slave Lake.

On news that Imperial Oil had found the genuine article at a depth of 170 ft., wildcat outfits poured into the country, but they soon gave up the chase. Casing abandoned by these "adventurous" concerns is today used as a fire guard around stove pipe in northern homes!

Most of the drillers were brought in from the Texas and Oklahoma fields. They were fine fellows, all of them, and the North certainly handed them a few surprises. Some of them expected to be wearing heavy underwear and fur clothing (in the northern summer) as soon as they left Edmonton! Wooding-up along the river was always hard, monotonous work for the deckhands, but it was fun with them. We were one day telling a lanky lad from Texas that he would soon be seeing the Midnight Sun (continuous daylight), to which he burst out with: "If I can go back to Texas and make them believe that, I'll be able to make them believe anything!"

They were greatly impressed by the Indians, the Northern Lights, and the great extent of wild life; pelicans flapping clumsily to their nesting place on Pelican Island, moose and caribou swimming the rivers with careless abandon, the harmless black bears, foxes scampering along the river banks, and the long processions of ducks and geese in flight. But I think they will remember most the hungry mosquitoes and "bulldog" flies that would pounce on one for a free lunch!

All the way down the Mackenzie missions have grown vegetables for years. The results would seem astonishing, if not impossible, were one to lose sight of the fact that the hours of sunlight in summer increase as one goes north. Deep frozen ground is another aid to cultivation. As the thaw proceeds the moisture rises by capillary attraction to the roots of the plants. One chap actually lugged a sack of "Irish apples" all the way from Fort Norman to Oklahoma! Whether or not the spuds helped to prove stories and statements of his northern adventure I have never learned.

Oil seepage along the Mackenzie River

Due to transportation costs and difficulties, wells at Discovery Wells were capped and the North resumed its slumber. Then, in May, 1930, Gilbert LaBine, prospecting along the shore of bleak and forbidding Great Bear Lake, discovered pitchblende (radium ore)!

Great Bear Lake, twice as large as Lake Ontario, is partly within the Arctic Circle. It is in the interior, and travelers to that section were few. It was strictly a game country. Remote and inaccessible though it was thought to be, hundreds of claims were soon staked by men who were flown in, hoping to strike it rich. Transportation of machinery and heavy equipment presented the only problem.

By sheer Herculean effort, the Bear River rapids were licked and a water route was opened. Large trucks haul heavy loads around the rapids and through eight-and-a-half miles of pipe line oil from Discovery Wells is pumped to storage tanks above the rapids for transfer to a 70,000-gal. tank at Fort Franklin, from where large boats relay freight and fuel oil 225 miles across Great Bear Lake to Eldorado Mine.

The search for the elusive metal was renewed with greater energy as the silent North began, at last, giving up her secrets. Soon other finds, of gold, were made at Great Slave Lake and Lake Athabasca. At the latter location, Consolidated Mining and Smelting Company is building a 1000-ton mill

Barge load of oil, being pushed ahead by the *Silver Queen*, heading up the Mackenzie River from Discovery Wells. Note snow-capped mountains in the distance

Erecting a new still, Discovery Wells

on the Box property. The mill will be increased in capacity from time to time and should eventually reach 5000 tons!

With mining activity at fever pitch, Discovery Wells came into her own. Now, at the location "a million miles from nowhere" and once considered far too far from civilization ever to be of any use, oil is refined and shipped by boat to Great Bear Lake, Great Slave Lake, Yellowknife River, Gordon Lake, and other mining areas, and gasoline for kickers* supplied to all the trading posts along the Mackenzie. At Discovery Wells, many men are employed each summer, and their quarters are the best in the North. Shipments are arranged by radio, and a tractor hauls the filled drums to the river to be loaded on barges of the *Silver Queen*, and other boats.

Imperial Oil tried for oil at three points. Only Discovery Wells, nestled smugly beneath the white-tipped Discovery Range, produced the goods, and the others were abandoned. Two years ago, company officials visiting one of the abandoned wells, on Bear Island, were surprised to see oil bubbling from the depths!

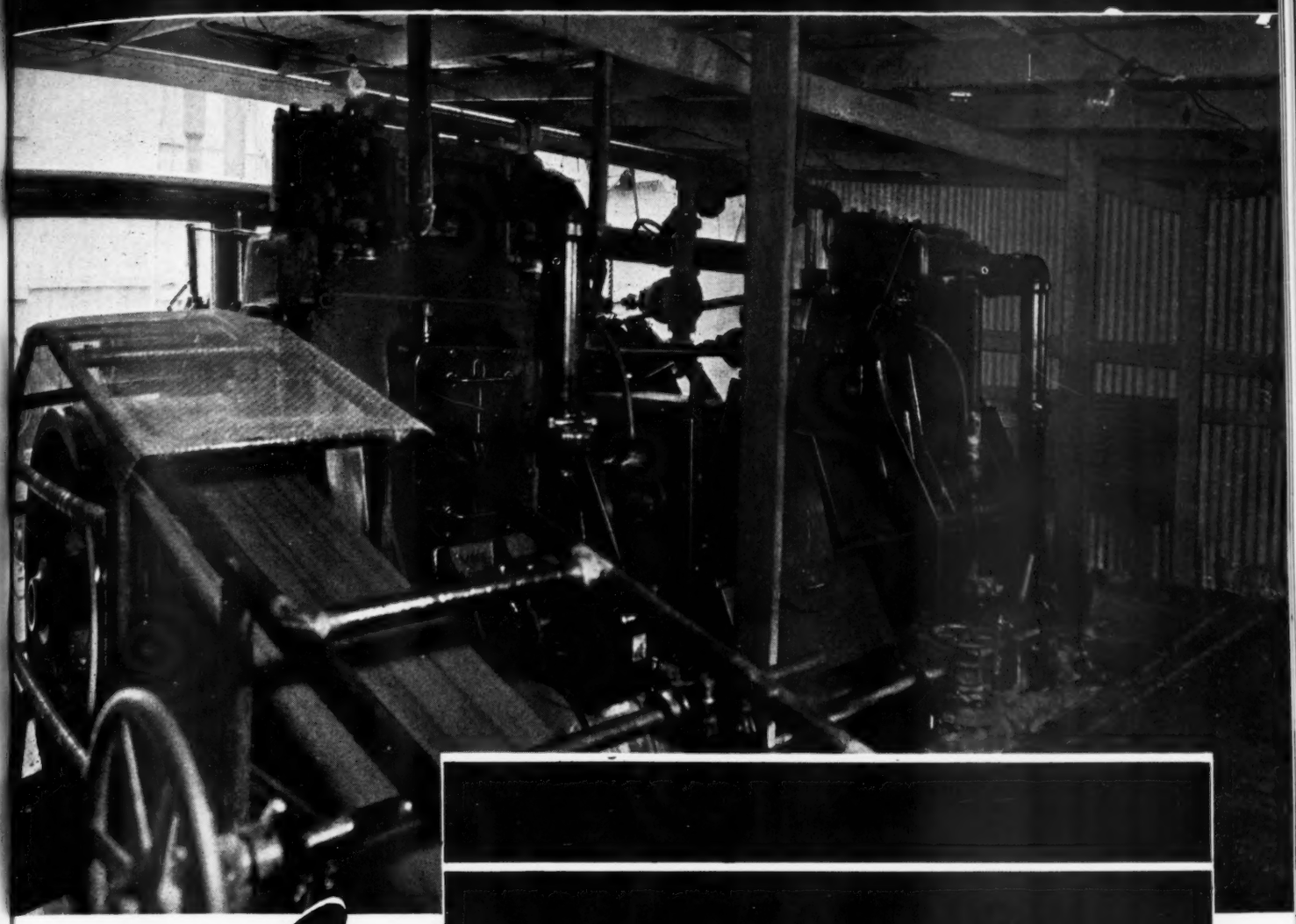
Time has wrought tremendous changes in the High North in the comparatively few years since geologists and drillers went to the fringe of the Arctic Circle to search for oil. Those liquid-treasure seekers would hardly recognize the country that exists today. The railway (now the Northern Alberta Railway) roadbed has been ballasted, and a car going off the track is news. The new Waterways is five miles down the Clearwater, near the mouth of the Hangingstone River, and three miles from Fort McMurray. In summer, fast Diesel-powered craft ply back and forth. Scows have gone where the grapevine twineth. Travel by boat is more comfortable today, and a rainstorm no longer provides a shower bath. Instead of sleeping on deck in a bedroll, there is a clean, well-ventilated cabin. Dogs are still used for short hauls and along the trap lines in winter, but along the main travel lanes they are seen no more.

Mail is now carried by airplane regularly throughout the year. The latest addition to the northern flying fleet, carrying radium ore concentrate from Great Bear Lake to Waterways, has a pay load capacity of two tons. Even the "moccasin telegraph", similar to the grapevine telegraph of the Civil War, has passed into oblivion. Radio stations for transmitting and receiving messages are situated at mining centers and important points throughout the country. There is no longer a Far North. Radio and the airplane have transformed that great empire into the Near North.

There are traces of oil in various parts of the North; an Indian once guided me to a "lake" of it! Just as Discovery Wells today supplies northern mines with oil, we may yet see oil from different areas below the Arctic Circle being piped or transported to the outside world. Stranger things have happened in that "wild fascinating country.

*Outboard motors.

Unloading casing at the end-of-steel



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Chemical Utilization of Gaseous Hydrocarbons

By B. KWAL

Part 2

Chemicals from Natural Gas

THE enormous quantity of natural gas produced with oil, especially during the early development of an oil field, is well known, and despite the progressive tendency towards conservation, large quantities have been wasted. The chief components of natural gas are the lower paraffin hydrocarbons, the designation signifying that such compounds have small affinity. In other words the paraffin hydrocarbons were once regarded as chemically inactive because of their apparent stability toward most reagents. The paraffin hydrocarbons have the general formula C_nH_{2n+2}, which signifies that for every carbon atom in the molecule there are twice as many hydrogen atoms, plus two.

To accomplish the chemical processing of paraffin hydrocarbons, it is first necessary to eliminate part of the hydrogen or replace it with something else. Methane, the chief constituent in natural gas, is the simplest hydrocarbon but the most difficult to attack. Ethane, propane, and butane exist in smaller amounts in natural gas. When heated sufficiently, saturated hydrocarbons split into carbon and hydrogen; however, when heated to a lesser degree, decomposition may be accompanied by formation of complex hydrocarbon mixtures. Therefore, under proper conditions methane and its homologs can be submitted to several different reactions.

In the mineral oil hydrogenation process, and in other processes, the formation of hydrogen and carbon dioxide by the interaction of natural gas and steam in the presence of catalysts is of great importance. Methane also reacts with steam in the presence of catalysts at temperatures as high as 900 deg. cent. to form carbon monoxide and hydrogen. This mixture can be considered as a starting material in several syntheses. For example, when the mixture is submitted to the polymerization process at atmospheric pressure, it will be transformed into saturated and unsaturated hydrocarbons and small amounts of oxidizing compounds. This process was invented by Fischer and Tropsch. The same mixture of carbon monoxide and hydrogen, when polymerized under moderate pressure, forms solid and non-volatile paraffin hydrocarbons. By interaction in the presence of various catalysts at high pressure the above-mentioned mixture will be transformed into a mixture of alcohols and other oxidized compounds. The resulting mixture is called "Synthol" by Fischer.

Another way of transforming paraffin hydrocarbons into a starting material for the manufacture of different chemicals is conversion into olefins by dehydrogenation under the influence of heat or partial oxidation. According to the free energy calculations of Francis[1], the direct removal of hydrogen from a paraffin to form an olefin having the same number of carbon atoms is possible only at high temperatures and to a limited extent. There is considerable division of opinion among investigators as to the mechanism of methane pyrolysis. Some technicians think that ethylene is a primary product of molecular disintegration of methane, whereas others maintain that acetylene is first formed. According to the theory of Fussteig[2], methane must be split into hydrogen and a CH_2 molecule, and then these residual carbon-hydrogen fragments are submitted to a polymerization process to form ethylene.

Olefins may be formed from the other homologs by the elimination of two hydrogen atoms. Thus ethane becomes ethylene, propane will be transformed into propylene, butane becomes butylene, etc.; however, the higher the saturated hydrocarbon the more complicated is its dehydrogenation. For example, propane can be split in two ways: it can be split into ethylene and methane, or it can be split into propylene and hydrogen. Of course, the progress of these reactions depends to a large degree upon operating conditions during the pyrolysis.

All these olefins are of great interest because of their greater chemical activity as compared to the paraffins and because of their ability to polymerize and to form addition products with other hydrocarbons.

Stanley and Nash[3] produced acetylene by pyrolysis of natural gas at very high temperatures, such as are caused by spark discharge. This product is of value for its hydration reaction to acetaldehyde, which is the starting material for preparation of acetic acid, acetic anhydride, and acetone. Acetylene also reacts with acetic acid to produce ethylidene diacetate, which can be decomposed by heat, in the presence of a suitable catalyst, to form acetic anhydride and acetaldehyde. Acetals have been formed by the interaction of acetylene with alcohols in the presence of mercury catalysts. Acetylene has recently been suggested as a starting material for the formation of di-isobutylene at high pressures[4]. Other products can be prepared from acetylene, such as vinylacetylene, divinylacetylene, chloroprene acetylene black, synthetic drying oil, quinaldine, vinyl acetate, crotonaldehyde, diiodacetylene, ethlidene ether of glycol, and pyrazole.

The effect of catalysts and increased pressure on the polymerization of olefins presents a very important field for research. For example, aluminum chloride and boron trifluoride are important catalysts causing olefin polymerization. There are several different Friedel-Craft reactions with aluminum chloride. The unsaturated hydrocarbons can be submitted to this reaction to produce alkylated aromatic hydrocarbons, alkylvinyl ketones, halogenated acid chlorides, etc. Lubricating oils can be produced from olefins by the action of aluminum chloride. These oils show some remarkable similarities to natural petroleum lubricating oils yet differ in many ways. According to Nugey[5], ethylene can be used in the manufacture of the new plastic resin, metastyrene. Such reactions are com-

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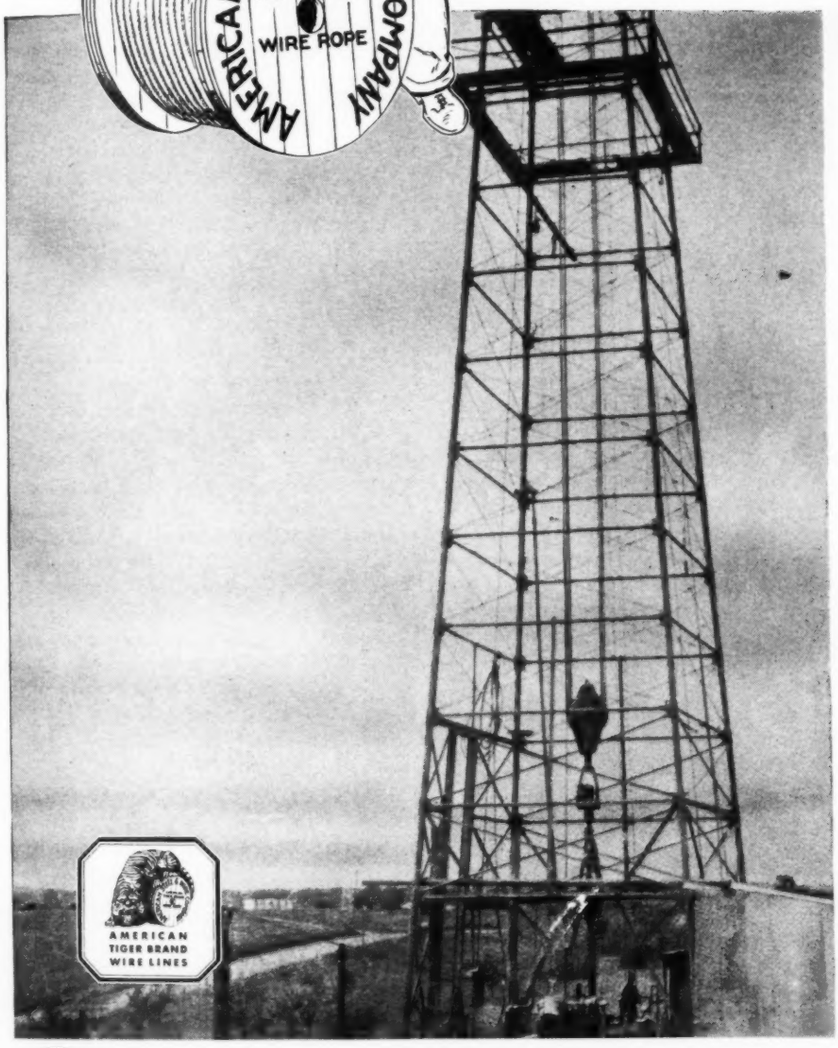

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plicated, and probably include the reaction of olefins with aromatics to form substituted aromatics, polymerization of diolefins and olefins to form resins, and reaction of diolefins with substituted aromatics to form resins.

As previously mentioned, the activity of the saturated gaseous hydrocarbons can be increased by displacing the hydrogen atoms. Chlorine is usually used for this purpose. All the hydrocarbons of natural gas react with chlorine under various conditions to yield chlorinated derivates, methane forming methyl chloride, dichlormethane, chloroform, and carbon tetrachloride. All these products are industrially important. Methylchloride is used as a refrigerant, methylene dichloride is a solvent for oils, fats, and resins; chloroform is used as an anaesthetic and as a solvent and extraction agent; and carbon tetrachloride is used as a solvent and extraction agent. Hydrochloric acid gas is a by-product of these reactions.

Ethane reacts more easily with chlorine than does methane, leading to the formation of six possible chlor-derivatives, ethylchloride, dichlorethane, trichlorethane, tetrachlorethane, pentachlorethane, and hexachlorethane. Ethylchloride is used as a local anaesthetic and as a refrigerant; dichlorethane is used in the manufacture of lacquers. Trichlor- and pentachlor-ethane have no industrial use but they are somewhat similar in their properties to ethylene dichloride. Tetrachlorethane is the best known organic solvent for rubber, resin, etc. Hexachlorethane, a white solid material having a penetrating odor, is used in combatting mosquitoes.

It is possible to submit ethane to the chlorination process in the presence of methane without causing appreciable chlorination of the methane, because, as previously mentioned, ethane reacts more readily than methane. Of course, all reactions depend upon such factors as heat, catalysts, and chemical reagents. The general process of chlorination is the action of chlorine on gaseous hydrocarbons in a reaction chamber at a temperature between 100 and 200 deg. centigrade. The hydrochloric acid gas is removed from the reaction products by washing them with water. As previously mentioned, the action of catalysts in this process is of great importance. Animal charcoal is regarded as the best for this purpose. Activated carbon, coke, iron, copper, and cupric chlorides can be used as catalysts with good results in the chlorination process.

Propane reacts more easily with chlorine than do ethane and methane. This hydrocarbon, however, forms such a great number of chloropropanes that in spite of the great technical interest in these reactions they are incompletely known. Schorlemmer[6] obtained by photochemical chlorination of propane only 1-chlorpropane. A more careful analysis of the product obtained under the operating conditions established by Schorlemmer using modern rectification equipment shows a ratio of about 60 percent 2-chlorpropane to 40 percent 1-chlorpropane. More recent work by Mason and Wheeler[7] indicates that both monochlorides are obtained in the thermal chlorination of propane. In rectifying these chlorides, 2-chlorpropane with a boiling point of 34.7 deg. cent. predominates in the first fraction, whereas 1-chlorpropane with a boiling point of 46.6 deg. cent. is the chief constituent in the later ones. We thus reach the conclusion that the chlorination of propane merits further investigation.

The chlorinated derivates of isobutane also are of industrial interest. This hydrocarbon can be chlorinated under proper conditions for the manufacture of the monochlor and polychlor compounds. In the photochemical chlorination of iso-butane 38 percent tertiary butyl chloride and 62 percent isobutyl chloride can be obtained. The monochlor compounds can be hydrolized to the corresponding alcohols.

Industrial development of chlorination of the pentanes greatly exceeds that of the other natural gas hydrocarbons. It is interesting to note that an industry[8] has been built in America around the chlorination of n- and isopentanes. Amyl alcohol and amyl acetates are produced from amylchlorides obtained by chlorinating a mixture of these hydrocarbons.

The chlorination is carried out as follows: a fraction of natural gasoline boiling between 82 and 102 deg. fahr., consisting of approximately equal quantities of isopentane and pentane, is vaporized and the vapors continuously admixed with chlorine during passage through a pipe still. The amylchlorides resulting are condensed, together with pentanes, which are removed by fractionation and recycled to the system. The amylchlorides, which are recovered in a practically pure state, are hydrolized with caustic and sodium oleate solution to yield the mixed amyl alcohols. Hydrochloric acid is recovered in this process by washing with water, which absorbs the gas.

The following additional substances can be produced from pentanes: secondary and tertiary amyl alcohol, pentasol, a mixture of amyl alcohols, pentaacetate, obtained from the acetylation of pentasol with commercial acid, mixed amylchlorides, amylene dichlorides, amylenes, diamylene, etc.

All in all, there are many methods now available for the chlorination of methane and its homologs. The reaction between these gaseous hydrocarbons and chlorine may be brought about thermally or photochemically; in the thermal vapor phase chlorination, in order to get the best yields it is necessary to adjust the conditions so that although complete or nearly complete reaction is effected, pyrolysis does not occur. The photochemical reaction depends on the fact that when a gaseous hydrocarbon and chlorine are exposed to sunlight, the mixture reacts with explosive violence. This phenomenon has been the subject of many investigations dealing with light effects. Ultra-violet radiation, mercury vapor light, blue light, etc., have been used with different results. The silent electric discharge also is used for this purpose with satisfactory result.

There are also possibilities in the conversion of gaseous hydrocarbons to other halogen derivatives. For instance, a variety of uses for methyl bromide have been suggested, including that of a fine distinguisher.

The oxidation of methane and its derivaties has received considerable attention for many years. The hydrocarbons react with oxygen in varying degree, depending upon the conditions influencing the reaction. Investigations have been carried out from many viewpoints and include such projects as the formation of formaldehyde, derivation of hydrogen and carbon monoxide from methane, and the dehydrogenation of butane to butylene. These oxidation reactions are similar to chlorination in many ways, because a great amount of heat is evolved and the time of the reaction is very short.

Explanation of the oxidation process involves two chief theories. The hydroxylation theory assumes that the molecular oxygen is split during the oxidation process in such a manner that each atom enters into reaction with a hydrocarbon molecule. If this hydrocarbon is methane, the reaction product will be methyl alcohol. Ethane would be transformed under the same operating conditions into ethyl alcohol. According to the second theory, the so-called peroxide theory, the molecular oxygen enters directly into reaction with the hydrocarbon molecule leading to the formation of a peroxide, which is then split into an aldehyde and water. For example, when methane is submitted to this oxidation process it will be transformed into the formaldehyde. In reality these two reactions take place in all oxidation of gaseous hydrocarbons. Of course, the

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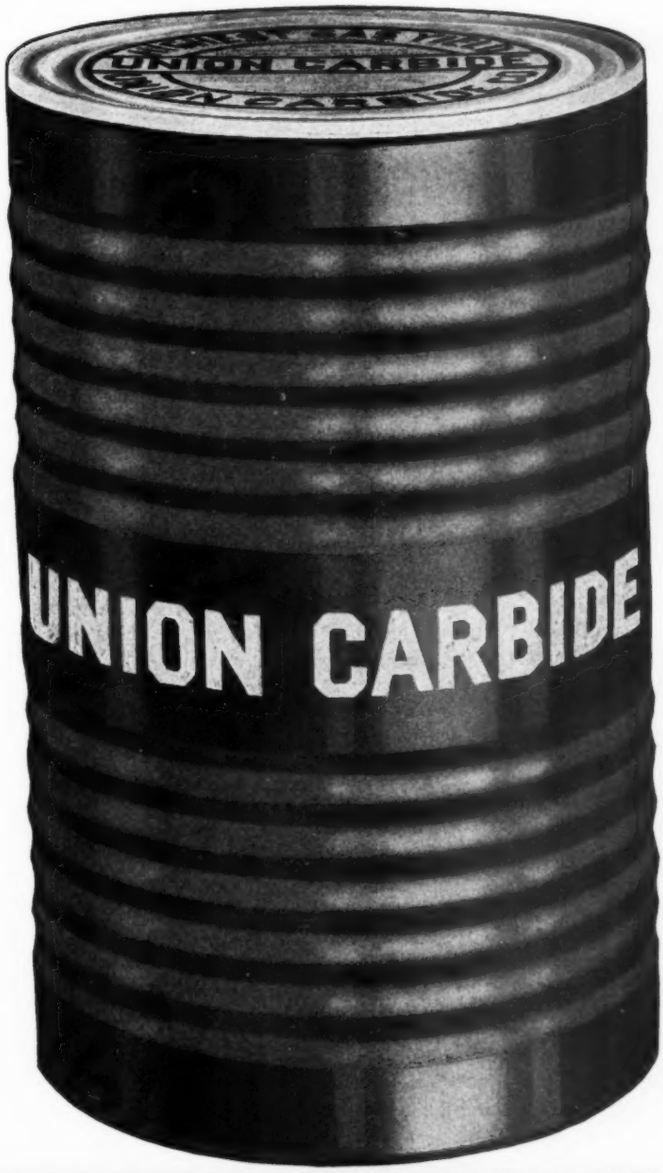

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composition of the product depends largely upon the temperature, pressure, period of reaction, and proportions of reactants.

Cooper and Weizewich[9] have stated that it should be safe to operate with methane at a pressure of 210 atmospheres and temperatures of 400 deg. cent. in the presence of less than ten percent of oxygen. The use of high pressures and lower temperatures favors an increased yield of alcohols, but in such processes, if conditions are not controlled there is the risk of explosion. Newitt and Haffner[10], using a reaction mixture consisting of nine parts methane and one part oxygen under a pressure of 100 atmospheres and temperature of 360 deg. cent. for a period of several minutes, found that the oxygen had disappeared and that the reaction was complete. The products of the reaction consisted of 17 percent methyl alcohol, 0.6 percent formaldehyde, carbon monoxide, carbon dioxide, and water. One feature of the oxidation process is the complexity of the products obtained, the complexity increasing as the molecular weight of the hydrocarbons increases.

Levis and Froelich[11] have oxidized propane at a pressure of 140 atmospheres at temperatures between 300 and 350 deg. cent.; these investigators have stated that under these conditions more than 40 percent of the oxygen may be accounted for in the liquid organic products. Viewing the results obtained we are forced to the conclusion that the main difficulties involve control rather than initiation of reaction. As the air is free and the natural gas is comparatively cheap and the value of the oxidized products is great, the oxidation process possesses economic importance.

Another economically important group of chemicals manufactured from methane and its homologs should result from their sulphonation by means of concentrated sulphuric acid; however, this reaction has not yet been thoroughly investigated. Worstall[12] has carried out the sulphonation of methane, ethane, propane, etc., but most of these reactions have been complicated and the reaction products have been complex mixtures not susceptible to easy identification.

A number of processes using other reagents have been described in literature on the subject and in patents. For example, Hoss, Hodge, and Vanderbildt propose the nitration of gaseous hydrocarbons by passing the hydrocarbon vapor through nitric acid heated to 108 deg. centigrade. This process gives a hydrocarbon-nitric acid vapor ratio of about 2 to 1. Two layers are formed in this operation, the upper consisting of nitro-paraffins and the lower of dilute nitric acid. The nitration of ethane, propane, butane, and iso-butane gave satisfactory results; however, negative results were obtained using methane.

Reaction between methane and ammonia takes place at high temperatures, resulting in the formation of hydrocyanic acid. The manufacture of hydrocyanic acid by the interaction of gaseous hydrocarbons and ammonia at temperatures between 1350 and 1450 deg. cent. has been proposed in many patents. For this reaction the surface of the chamber must be composed of an inactive material, and to prevent decomposition of the reactants, the latter are heated to the reaction temperature as quickly as possible.

Methane has been suggested as an agent for the reduction of magnetite and limonite, the reduction of limonite occurring at a temperature of about 700 deg. centrigrade.

It can be seen that natural gas hydrocarbons have an important place not only in the oil refining industry, in which they are polymerized into gasoline-like hydrocarbons of high octane number, but also in the chemical industry, in which they are the raw material for a quantity of valuable chemicals. That is why the oil refining industry begins to enter into the field of the chemical industry.

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The Metallurgist Enters the Oil Refinery[1]

PERHAPS in no industry has metallurgy played such an important part as in petroleum refining. Here, metal equipment must operate at temperatures ranging from minus 70 deg. fahr. to plus 2000 deg. fahrenheit. The sulphur of the crude as well as the chloride salts contained in the water associated with the crude can be vigorously corrosive under certain conditions. The various chemicals used in treating the products also are often quite corrosive. The high temperatures used, accompanied by pressures up to 3000 lb. per sq. in. tend to produce "creep" stresses in steels.

Nickel-alloy cast irons, steels, and highly-alloyed materials as well as Monel play an important part in resisting the destructive forces encountered.

Steels containing from two to four percent nickel and Monel are widely used in the sub-zero temperature region in which paraffins are removed from lubricating oils. Monel also finds application in connection with acid treating. The heat-resisting alloys of chromium and nickel are generally used as tube supports in fired coils and as dampers, ducts, etc.

The 18 percent chromium, 8 percent chromium-nickel alloy possesses high resistance to sulphur-bearing compounds at high temperatures, and is used as tubing, screens, and surfacing materials. At low temperatures, where water is condensed, Monel offers high resistance to the sulphur compounds and is found in use as orifices of meters, swing pipe cables, and as a protective facing for parts of towers. Because of their high degree of hardness, heat-treated (K) Monel pump rods and shafts have gained favor. Monel pumps, rods, valves, springs, and liners are used in handling corrosive distillates and materials.

One outstanding contribution to refinery metallurgy is (Ni-Resist) cast-iron, which possesses high resistance to a large number of corrosive media at moderately elevated temperatures. It is used as pump liners and casings to handle reflux, naphtha, and corrosive crudes and for the liner of compressors handling refinery gases. It also finds a variety of applications in the fractionating towers for bubble caps and trays, for the body of valves and cocks and, owing to its low growth up to 1500 deg. fahr., as a damper material and as tube supports for parts of coil settings to operate at 1200-1500 deg. fahrenheit. (Ni-Resist) liners are in service handling acid sludge, corrosive reflux, and acid-treated stock.

Monel and 70/30 Cupro Nickel tubes appear to offer refineries a solution to condenser difficulties where brackish waters are used as the cooler-ant. Present installations are being observed with interest as a suitable condenser tube is a pressing problem.

[1]Excerpt from an article by B. B. Morton in *Inco*, Vol. XV, No. 2.

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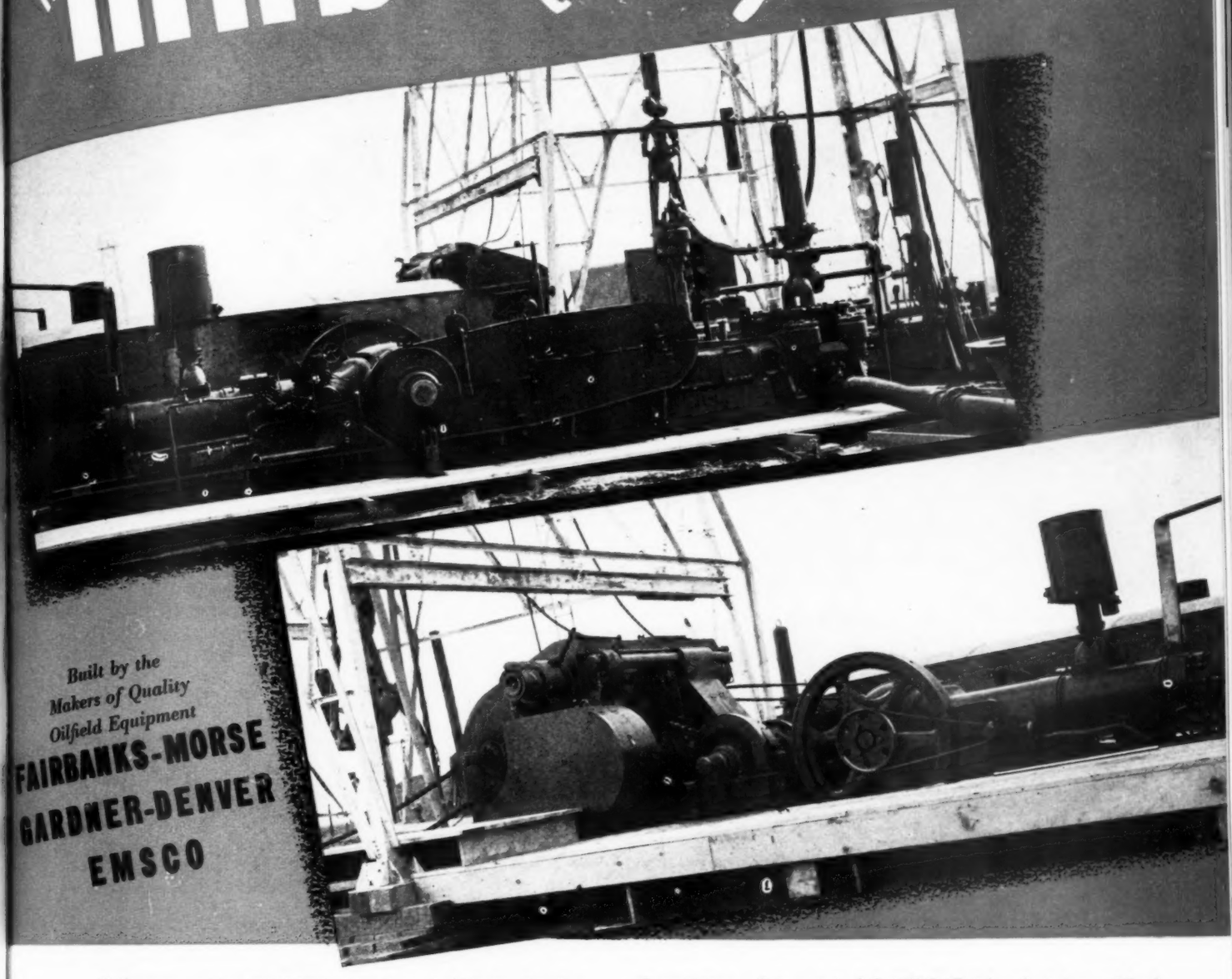

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CONTINENTAL

Cathodic Protection of a Large Gas Line Passing Through a Steel Casing Filled with Salt Water and Mud*

By GUY CORFIELD

Research Engineer, Southern California Gas Company

SEVERAL years ago, during the construction of the Southern Fuel Company's 26-in. natural gas transmission line from Kettleman Hills to Long Beach, California, it was necessary to go under a paved and heavily-travelled highway (Anaheim Street) in a reclaimed area, close to sea level, where the soil consists of salt water-impregnated sand and mud dredged from the nearby Long Beach Channel.

As will be seen in Fig. 1, this underground crossing was accomplished by installing a 30-in. steel casing at a depth of 13 ft. below the highway, and running the 26-in. pipe through this casing, the pipe angling upward on both sides to a normal depth. Because of the high water table and the sand-mud texture of the soil, installation was difficult. Open-top caissons were sunk on each side to keep back the water and moving soil; the casing was pushed through in short sections, welded together as inserted; and the pipe was likewise pushed through the casing in short sections, welded together as inserted. The inside of the casing was heavily greased, and the pipe sections and welds were protected heavily and as carefully as possible with grease covered with several layers of fabric wrapper and bituminous "hot" coating. The two ends of the casing were left open. The remainder of the pipe angling upward from both ends of the casing, and also that at normal level, was heavily protected through the area of "bad" soil with grease, wrappers, and coats of bitumen.

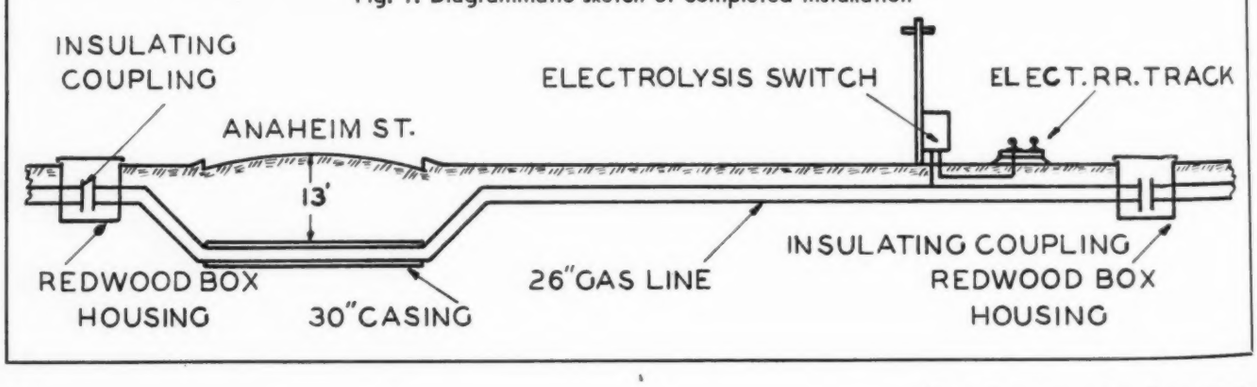
It will also be seen, in Fig. 1, that an electric railway track runs alongside the highway and crosses the pipe line a short distance north. Inasmuch as the 26-in. pipe is connected to a number of other underground pipes in the immediate vicinity, an extensive stray-current gathering system was set up and an active electrolysis hazard created, with respect to the 26-in. pipe, as far south as the highway; in addition to this, the section in the casing under the highway and the risers on both sides, were perhaps in a particularly precarious position because of possible abrasions and/or imperfectly protected welds due to construction difficulties; still further, the pipe in the casing, and the risers, would probably be anodic to the remainder of the pipe line because at this lower level they would be below the water table probably the year round, with the casing filled with salt water, giving rise to differential aeration phenomena because of exclusion of oxygen. It was, therefore, evident that this situation needed careful attention.

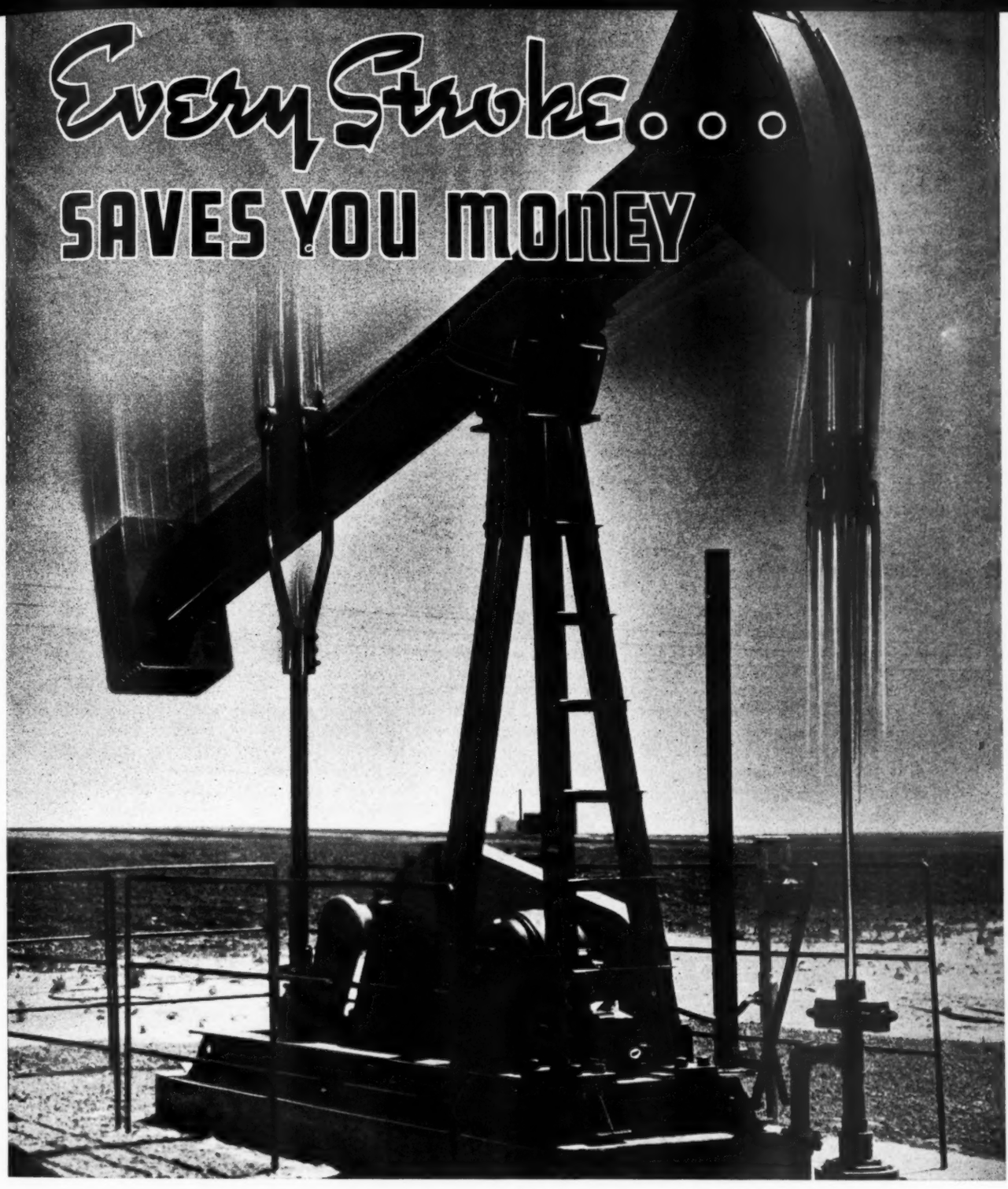
The first thing done was to bond the pipe to the electric railway track, as shown in Fig. 1 in the detail surrounding the electrolysis switch. This installation consisted of connecting the pipe line to the track with a heavy stranded copper cable in which was inserted an electrolysis switch, the function of which was to interrupt the current at times of reversal when the track became positive and would "flood" the pipe line; otherwise there would have been considerable of this flooding, because a short distance away the electric track crosses a steam railroad right-of-way, and all cars have to stop and start at this point, consequently pulling heavy surges of current. The switch installed is of the Pacific Electric type, and is described by B. A. Williamson in Pacific Coast Association Proceedings, Vol. 26, 1935, p. 64. This installation relieved the situation to the extent that during the daily 18 hours of electric train operation the pipe line potential was reduced considerably below its former potential; it was not brought down, however, to or below earth potential, and during the six night hours when the electric trains are inoperative no lowering of potential was obtained. Because of the corrosive soil, and other factors previously discussed, this was not considered a satisfactory condition, and fears were confirmed during an examination of the risers from the casing when corrosion was disclosed on an imperfectly protected weld.

It was then thought that if a short section under and on both sides of the highway was electrically insulated from the rest of the pipe line, this section would be lowered sufficiently by the electric railway influence to receive cathodic protection, and it was finally decided to put an insulating

*Paper presented at National Bureau of Standard's Fourth Soil Corrosion Conference, Washington, D. C., November, 1937.

Fig. 1. Diagrammatic sketch of completed installation





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coupling immediately south of Anaheim Street, and another immediately north of the electric railway track. This, as shown in Fig. 1, electrically isolated a section of minimum length while still using the electrolysis bond connection. The couplings, 26 in. in diameter, were assembled in the shop, to include short lengths of pipe on either side, electrically tested, and then welded into the pipe line; they consist of bolted flanges, with an insulating (composition) disc between the flanges, insulating tubes around the bolts, and insulating washers under the bolt heads and nuts. Each coupling is completely enclosed in a waterproof redwood box having a tight-fitting cover, so that earth can not get in to cause a short circuit or joint electrolysis. The net result of this final installation was to lower the isolated section below earth potential, to a value of approximately 1.0 volt maximum, 0.4 volt minimum, and 0.5 volt average. Even though the electric trains are inoperative during the night hours, the pipe potential remains below earth and does not rise above the minimum shown above. The main pipe line on both sides of the isolated section is at approximately earth potential, so that the voltage across the insulating joints is the same as given above for the below-earth voltage of the isolated section. The drainage bond carries an average of 10 to 15 amp. during the period of electric railway operation.

The above electrical conditions would presumably place this isolated section of pipe under complete cathodic protection. However, it was thought that the section *within the casing* might not be receiving such protection, or only part of it, because of the shielding effect of the casing, which might allow galvanic corrosion to proceed within it, on the surface of the 26-in. pipe. To obtain some information as to the behavior of the pipe in the casing, and verification of the effectiveness of the lowered potential as described, unprotected samples consisting of pipe fitting assemblies, and coupons, were installed underground, at pipe level, as shown in Fig. 2.

It will be noted that:

(a) Pipe fitting assemblies A, B, C, D, E and F, G, H, I, J were constructed so as to be miniatures of the 26-in. pipe in the 30-in. casing, with 1-in. by 26⅛-in. pipes (samples C and H) enclosed in 2-in. by 24-in. casings, the space between the casing and pipe being filled with wet corrosive earth from the test site.

(b) Assembly F, G, H, I, J and coupons 9 and 14 were connected to the undrained portion of the pipe line immediately north of the north insulating joint.

(c) Assembly A, B, C, D, E and coupons 6 and 7 were connected to the drained portion of the pipe line immediately south of the north insulating joint.

(d) Coupons 2, 8, 11, and 12 were unconnected to the pipe, in the vicinity of the north insulating joint.

(e) Coupons 4, 5, and 13 were connected to the pipe immediately north of Anaheim Street, and coupons 1, 3, and 10 unconnected to the pipe at the same location.

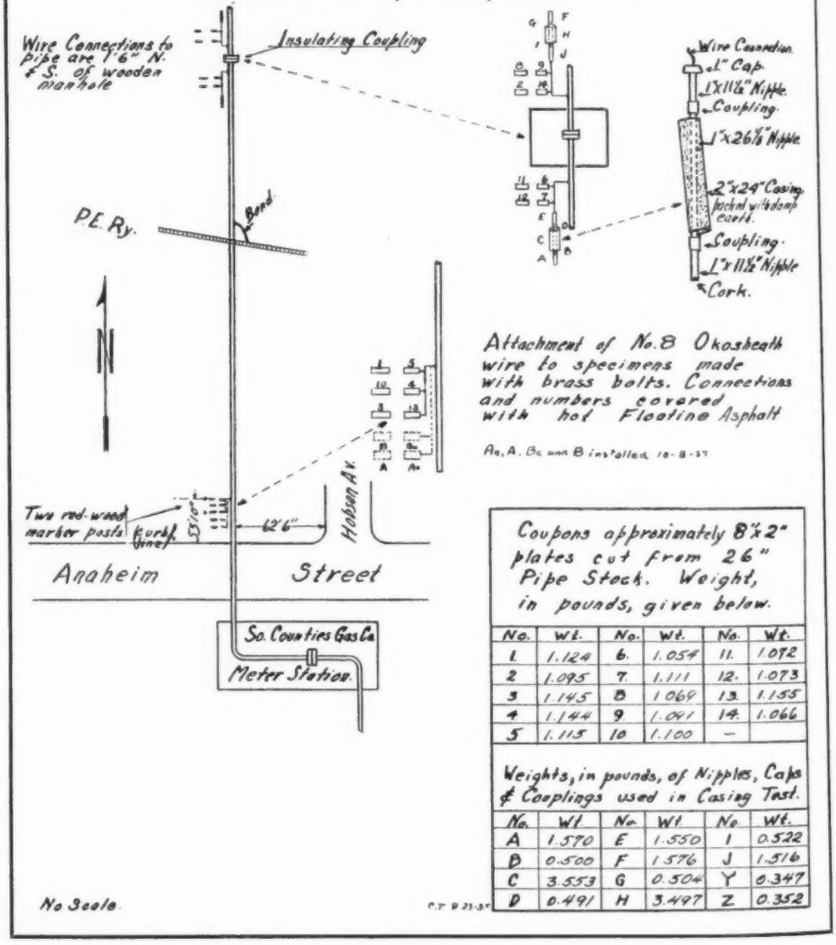
In the case of the "connected" coupons, connection was made to the pipe

(Continued on Page 83)

TABLE I

No.	Kind	Loss in weight, lb. per sq. ft. of exposed surface.
		Undrained
F	Nipple	0.282
G	Coupling	0.251
H	Nipple (encased)	0.101
I	Coupling	0.225
J	Nipple	0.316
9	Coupon	0.486
14	Coupon	0.486
	Average	0.307
		Drained
A	Nipple	0.016
B	Coupling	0.000
C	Nipple (encased)	0.017
D	Coupling	0.040
E	Nipple	0.024
6	Coupon	0.027
7	Coupon	0.018
13	Coupon	0.000
	Average	0.020
		Non-connected
2	Coupon	0.297
8	Coupon	0.351
11	Coupon	0.279
12	Coupon	0.288
3	Coupon	0.400
3	Coupon	0.450
	Average	0.333

Fig. 2. Sketch of installation of Corrosion Specimens for Southern Fuel Company at Anaheim Street, Long Beach, made September 12, 1935. Objectives: (1) To determine the presence or absence of corrosive influences on the insulated and non-insulated portions of the pipe. (2) To ascertain whether the portion within the casing under Anaheim Street is protected as effectively as the portion without



Coupons approximately 8"x2" plates cut from 26" Pipe Stock. Weight, in pounds, given below.

No.	Wt.	No.	Wt.	No.	Wt.
1	1.124	6	1.054	11	1.092
2	1.095	7	1.111	12	1.073
3	1.145	8	1.069	13	1.155
4	1.144	9	1.041	14	1.066
5	1.115	10	1.100	—	

Weights, in pounds, of Nipples, Caps & Couplings used in Casing Test.

No.	Wt.	No.	Wt.	No.	Wt.
A	1.570	E	1.550	I	0.522
B	0.500	F	1.576	J	1.516
C	3.553	G	0.504	Y	0.347
D	0.491	H	3.497	Z	0.352

(Continued from Page 80)

by stranded copper wire; the wire was attached to the assembly or coupon by bolt and nut and the connection, and wire for a foot or two back, heavily protected with bitumen to avoid galvanic effects. All assemblies and coupons were carefully weighed, as shown in the table in Fig. 2.

Approximately 13 months later all the assemblies and coupons (except coupons 1, 4, 5, and 10) were exhumed and the component parts cleaned with ammonium citrate solution (to remove corrosion products) and again weighed, and the loss of weight in each instance reduced to lb. per sq. ft. of exposed surface.

The results of this test are shown in Table 1. It will be seen that:

1. The undrained samples show 0.307 lb. per sq. ft. average loss; the drained samples 0.020 lb. per sq. ft. average loss; the unconnected samples 0.333 lb. per sq. ft. average loss. This indicates very satisfactory general effectiveness of the drainage, with loss that is negligible, if not entirely due to handling of test pieces.
2. The undrained nipple in the casing (test piece H) shows 0.101 lb. per sq. ft. loss, whereas the corresponding drained nipple (test piece C) shows 0.017 lb. per sq. ft. loss. This indicates that:
   (a) A casing affords some protection to a buried pipe (inasmuch as the average loss of uncased undrained samples was in excess of 0.3 lb. per sq. foot.
   (b) A casing does not prevent or reduce the effectiveness of cathodic protection, by normal methods, of a pipe contained therein.

It is therefore considered that the various steps outlined in this discussion have been effective, and a serious electrolysis and corrosion hazard has been converted into a satisfactory operating condition, with the pipe section in question receiving adequate cathodic protection.

SELECTION OF ALLOY STEELS

THE selection of an alloy steel for any definite application involves many factors, including size and intricacy of section, strength level at which toughness and ductility are required, manufacturing routine, economic factors, and many others. This complex picture emphasizes the necessity for a proper inventory of the requirements. A steel suitable in one plant may not be the optimum for similar parts in another, due to some difference in certain factors involved.

It is a well-known fact that the ability of a steel to develop hardness increases with an increase in carbon. In sections of any size, however, the maximum hardness will be found at the outer surface layers, decreasing rapidly in the inner portions. Coincident with this, in carbon steel, are lack of response to the milder quenching media and the dangers of increased warpage, distortion, and cracking.

In order to obtain the most desirable combination of strength, ductility, and toughness in a piece of steel, it must be hardened by quenching and then tempered or drawn back to the desired strength level. The efficiency of the treatment depends on the completeness of the hardening reaction. In order to harden steel fully, it must be heated to a temperature above the upper critical point and cooled at a rate sufficiently fast to retain martensite, which is the microconstituent of all hardened steel. If the cooling speed is below this critical cooling rate, the steel will not fully harden.

The selection of a cooling medium will influence the results obtained. The most common media—water, oil, and air—possess limited capacity to develop the desired physical properties. Moreover, these media, used in connection with unalloyed steels, may cause sufficient cooling gradient to crack the part, due to internal stresses.

The presence of an alloying constituent like nickel increases depth hardening. In other words, the hardness gradient between surface and inner portions is minimized.

In addition to their effects on depth hardening, alloying elements greatly reduce the "critical cooling rate," or the minimum rate at which heat must be abstracted from the steel during the quench to insure full hardness. The fact that alloy steels harden completely in oil, whereas carbon steels require water or brine, is explained by this property. When properly alloyed with chromium and molybdenum, nickel will reduce the cooling rate to so marked an extent as to render a steel air-hardening. This alloy combination therefore lends itself to large forgings, particularly at high strength levels.

Nickel tends to increase hardness, elasticity, and strength, without corresponding loss in ductility. The critical points and the eutectoid ratio are lowered by nickel. A depressed critical point lowers the hardening temperature, thus minimizing heat-treating distortion, scaling, and wear and tear on the furnace equipment. By lowering the rate of transformation, nickel exerts a refining action on the ferrite and pearlite, thereby inhibiting grain growth and embrittlement. One of the fundamental functions of an alloying element like nickel is to impart high strength along with toughness, or superior toughness at a given strength level.

Grain size has a definite effect on the hardening characteristics and physical properties of steels. On a standard A.S.T.M. chart, which lists eight sizes, Nos. 1 to 5 are considered "coarse grained" and are generally characterized by complete carbide envelopes. Grain sizes 5 to 8 are considered "fine grained." These steels are tougher, possess higher impact strengths, and are less liable to crack or distort in hardening than coarse-grained steels of similar composition. The coarse-grained steels carburize at a somewhat faster rate and possess greater hardenability. Hence it is obvious that a fine-grained steel is desirable for most, though not by any means all, applications.

It is becoming generally recognized that, for a great many applications, the tensile strength is only partially indicative of the suitability of a given material. Factors of fatigue and impact resistance are often more important. A careful investigation into the fatigue resistance of normalized forgings of rather heavy sections such as are used in locomotive construction or heavy shafting has shown the influence of high carbon content in reducing the ratio of fatigue resistance to tensile strength. As tensile strength and actual fatigue strength go down with carbon content, it becomes necessary to resort to a means of reducing carbon without a sacrifice in strength. This may be effected through the introduction of nickel.

A great many fatigue failures are induced by stress concentrations due to the notch effects introduced by poor design, tool marks, etc. In many cases, particularly in the harder steels, as increase in strength, although accompanied by higher fatigue resistance in tests on smooth, polished test pieces, will result in quicker failure under these conditions because stress-concentration effects become more pronounced as hardness goes up. The superiority of nickel steels over carbon steel is maintained in the presence of stress-concentration effects. However, designs embodying bad stress concentrators represent poor engineering, and should be avoided in practice.

—*Nickel Steel Topics.*

Application of Electrical Logging Methods to West Texas Problems*

Part 2 (Concluded)

By

W. J. GILLINGHAM and W. B. STEWARD†

Location of Oil Pays

OIL pays, as has been previously explained, also give a cool anomaly on the temperature curve, except that the anomaly is much less pronounced than that due to gas under similar conditions of mud weight and time of circulation. However, if a light mud is employed and the temperature survey is made several hours after circulation, quite distinct anomalies will result. Fig. 4 shows several examples of the location of oil pays by temperature measurements. The second example is extremely interesting since no cooling effect was apparent even though several runs were made. This well produced for only three months before going dead. It must be emphasized that the degree of cooling is not proportional to the potential production of the well, since it is impossible to allow for such factors as weight, viscosity of mud, time after circulation, etc.

*Presented at the Spring Meeting of the Mid-Continent District, A.P.I. Division of Production, Herring Hotel, Amarillo, Texas, February 17-18, 1938.

†Schlumberger Well Surveying Corporation, Midland, Texas.

PRODUCING WELLS—Static Conditions

After a well has actually been on production, the thermal anomalies generated by the gas-expansion are naturally much larger than is the case in an ordinary drilling well in which a very small gas production is caused by circulation. Consequently, it is very much easier to determine the source of the gas in this type of well than ordinary drilling wells. A long circulation after the well has been killed naturally decreases the anomaly, nevertheless the

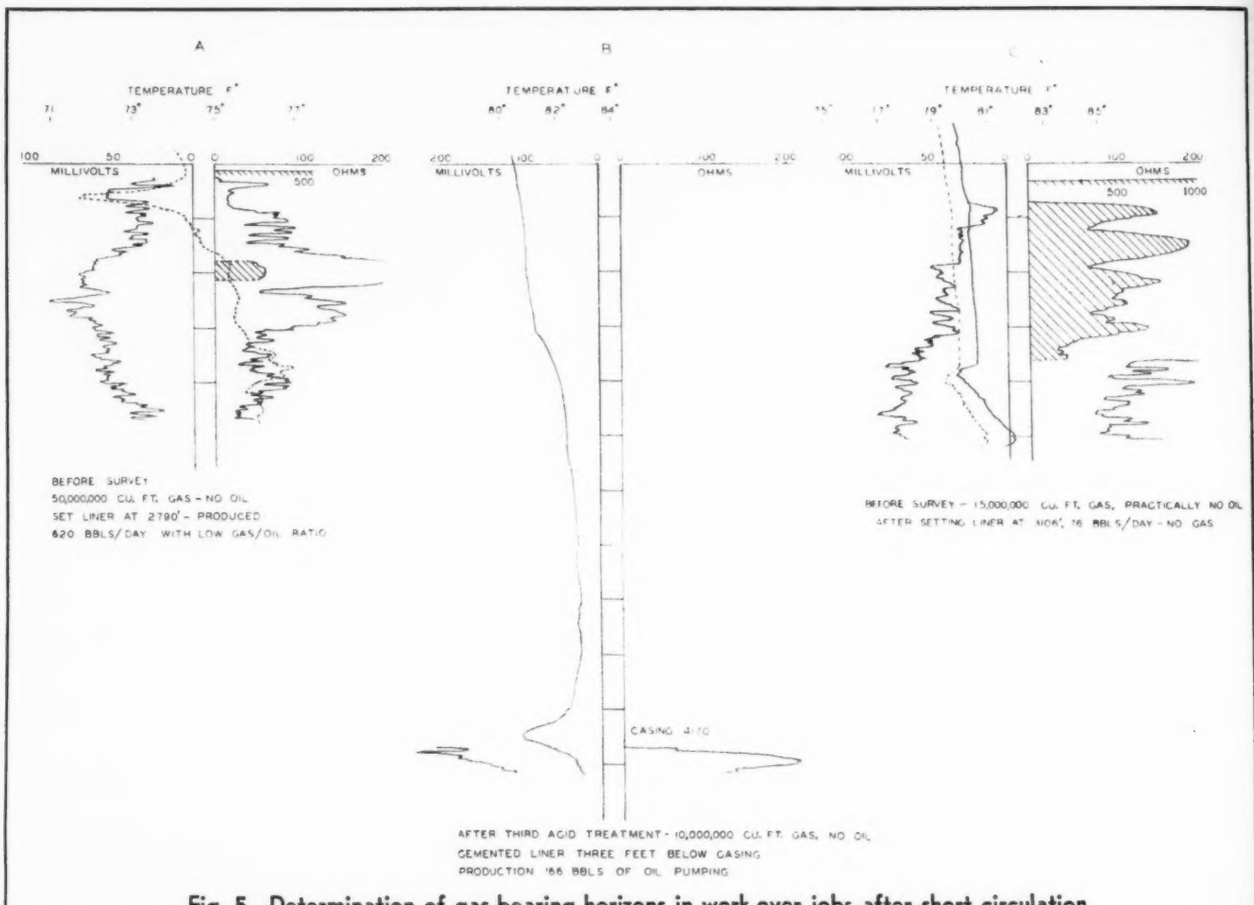


Fig. 5. Determination of gas-bearing horizons in work-over jobs after short circulation

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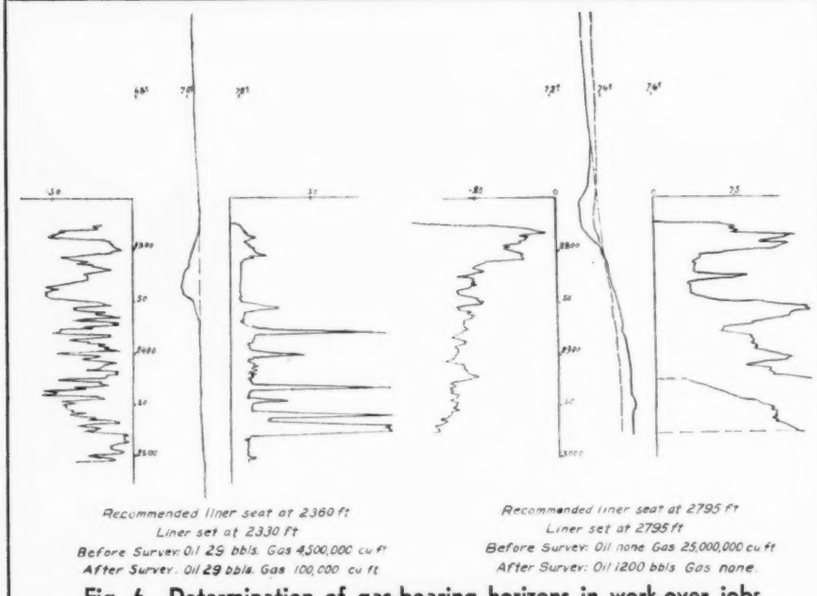
Recommended liner seat at 2360 ft
Liner set at 2330 ft
Before Survey: Oil 29 bbls. Gas 4,500,000 cu ft
After Survey: Oil 29 bbls. Gas 100,000 cu ft
Recommended liner seat at 2795 ft
Liner set at 2795 ft
Before Survey: Oil none Gas 25,000,000 cu ft
After Survey: Oil 1200 bbls Gas none.

Fig. 6. Determination of gas-bearing horizons in work-over jobs after long circulation

location of the gas pay remains easy. Fig. 5 shows examples of the location of gas under these conditions.

Well A blew wild for three days making 50,000,000 cu. ft., and was killed with difficulty. The source of the gas is shown by a very striking anomaly at 2725-2786 ft., which corresponded very clearly to a sand section on the electrical log. The electrical log showed a lime section at a depth of 2786-2810 ft., and by setting a liner at 2790 ft. and cementing the well was brought back on production for 620 bbl. a day with so little gas that it hardly flowed.

Well B was a small well with a low gas-oil ratio until the third acid treatment, after which it turned into a large gasser. A temperature curve made shortly after the well had been killed showed quite clearly that the gas was leaking from behind the casing, the cement having evidently been eaten away

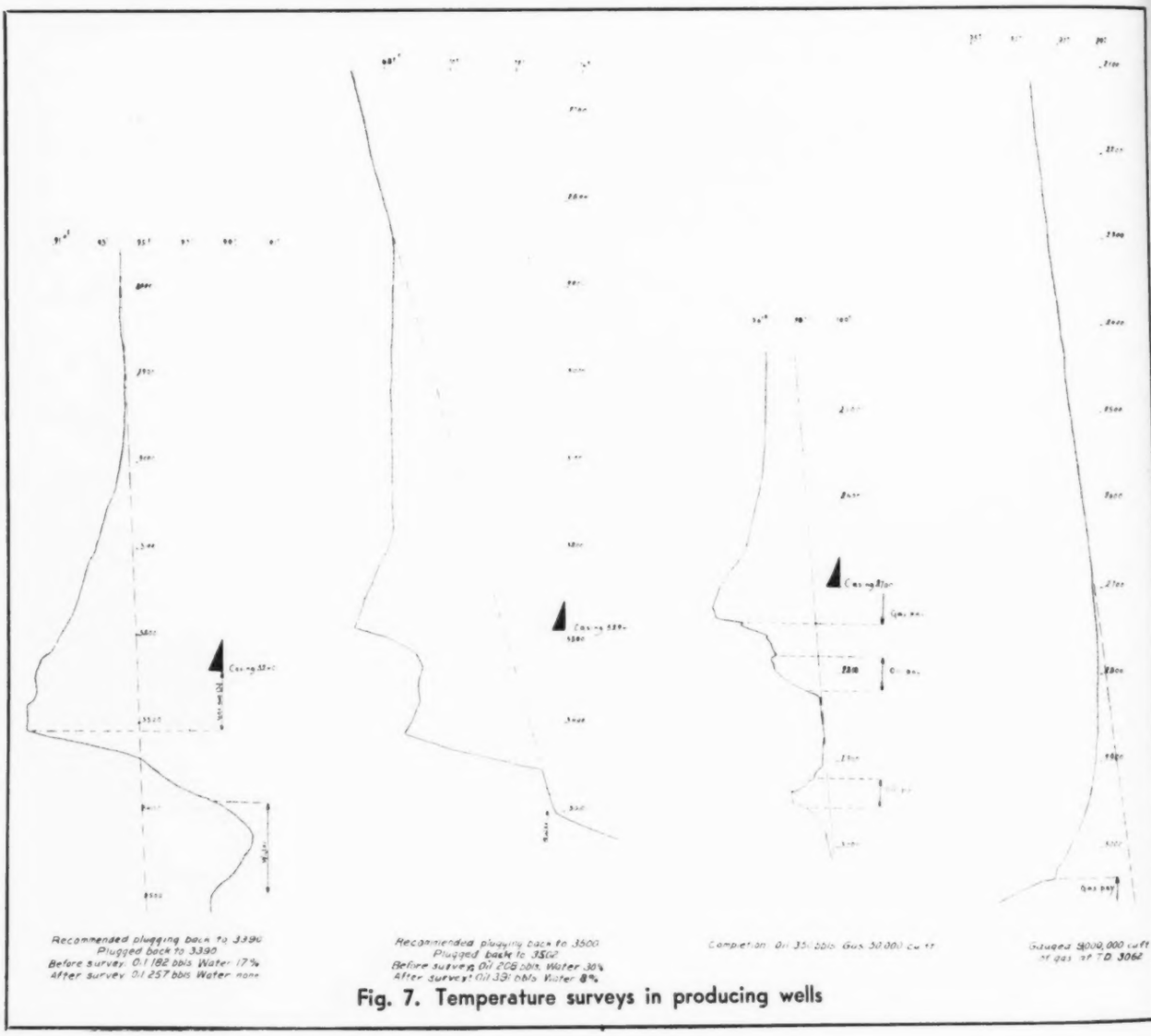
Recommended plugging back to 3390
Plugged back to 3390
Before survey: Oil 182 bbls Water 17%
After survey: Oil 257 bbls Water none
Recommended plugging back to 3500
Plugged back to 3502
Before survey: Oil 208 bbls Water 30%
After survey: Oil 331 bbls Water 8%
Completion: Oil 35 bbls Gas 30,000 cu ft
Gauged 9000,000 cu ft of gas at TD 3062

Fig. 7. Temperature surveys in producing wells

The above photograph shows a core taken with a Hughes "Type J" Core Bit on the Thomas No. 3, Parr Ranch, in Duval County, Texas. It's the kind of core you need – it's the kind of core you get with Hughes Core Bits.

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by the acid. A stub liner was set and recemented and the well brought back for 166 bbl. a day, pumping.

Well C produced before the survey 15,000,000 cu. ft. of gas and practically no oil. Setting a liner at 3106 ft. in the dense lime indicated by the resistivity and S. P. curves, the well was brought back on production with a low gas-oil ratio.

Fig. 6 shows examples in which the wells were killed by a long circulation. As was to be expected in these cases, the thermal anomaly was much less than in the cases previously discussed. The diagram is self-explanatory.

The ideal conditions for this kind of survey are for the well to be killed with mud and the mud circulated. In the case where the well is killed by dumping water without circulating, however, satisfactory results can still be obtained.

Dynamic Conditions

It is quite obvious that the ideal condition under which to make a temperature survey is when the well is actually producing, since under these conditions the thermal anomalies will be the greatest. Hence the oil and gas pays are clearly seen and even water can be satisfactorily located by this type of survey. Fig. 7 shows examples of surveys made under these conditions.

Oil Surveys

It is common practice in the Permian Basin to set casing to the top of the producing horizon and to drill from there on with oil in order to prevent the flooding of the oil pays with water. If cable tools are used for this purpose it is very difficult to pick the base of the gas; if rotary is used, it is extremely difficult to locate either the base of the gas or the pay section. If the well is shot without this valuable information, a well with a high gas-oil ratio may result.

A recently perfected technique permits the making of an electrical survey in wells filled with oil. Temperature surveys are made with the usual thermometer and in the usual manner. By swabbing the well down and making the survey when the well is filling up, very complete information is given, since the temperature curve is made under dynamic conditions and the oil and gas pays are clearly seen. Fig. 8

(Continued on Page 91)

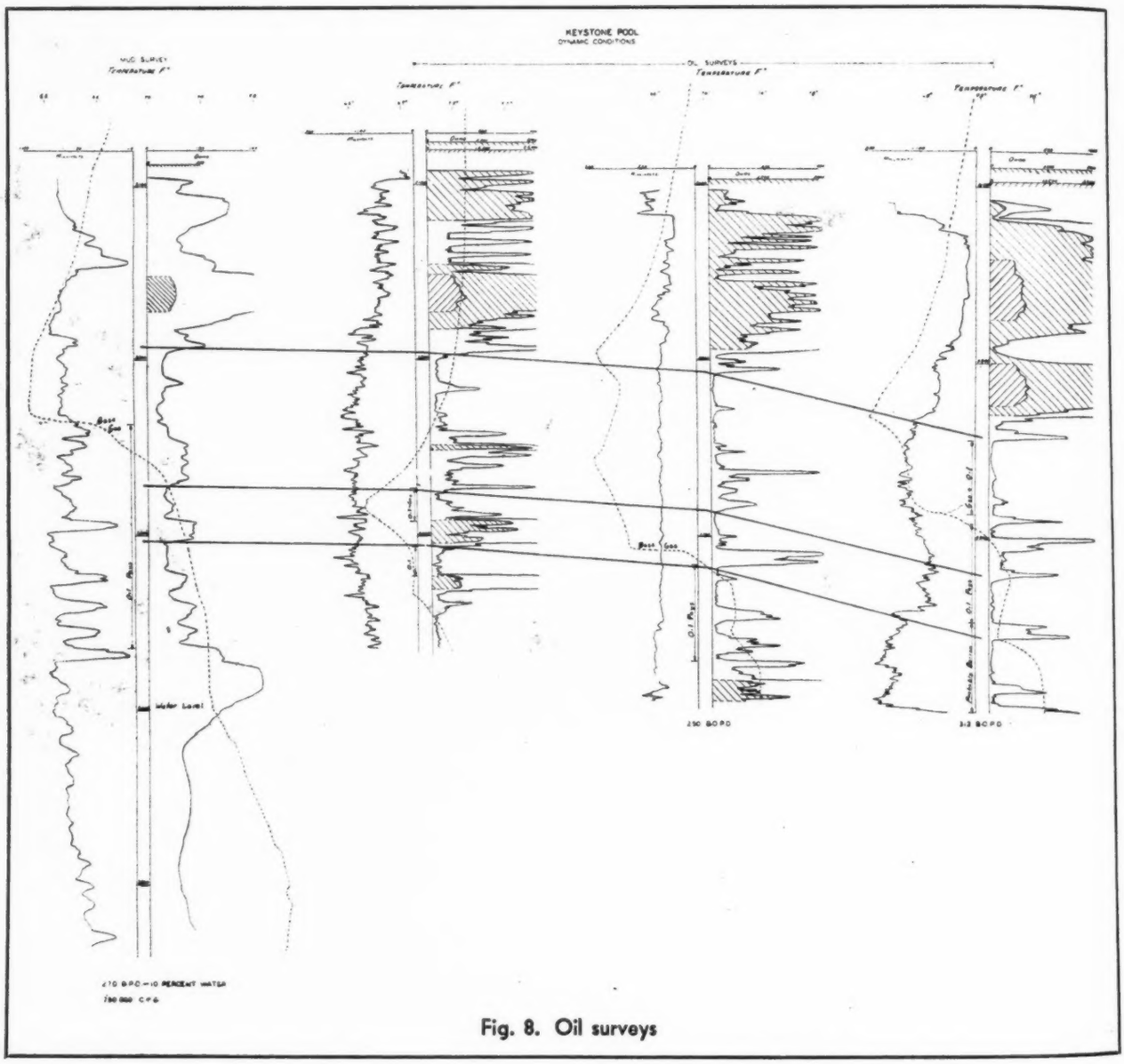

Fig. 8. Oil surveys

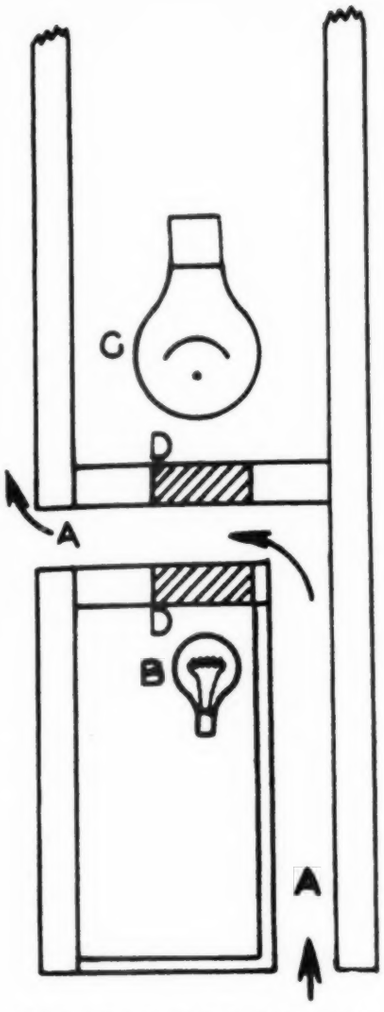

Fig. 9. Sketch of Dale instrument

(Continued from Page 88)

shows some examples of this type of survey. The good correlation between surveys made in oil and mud is to be noted and especially the sharpness of the resistivity curve when made under the former conditions. The excellent way in which the resistivity curve correlates from well to well is also to be noted.

The temperature curve indicates very clearly the base of the gas and the location of the oil pays; the resistivity log, on the other hand, differentiates very clearly between barren lime, high resistivity, and porous lime or sand, low resistivity. This information shows the best location of the shot, and the best location for the packer to shut off the gas, i. e., a tight lime break as shown by the resistivity log. Also the information derived from these logs will prove of great value later when reworking the well becomes necessary to shut off gas or encroaching water. This kind of survey is becoming more and more generally used even where cable tools are used for drilling, since the same technique can be applied where there is no fluid in the hole. To date some 50 such wells have been surveyed.

Dale Photoelectric Surveys

The Dale Photoelectric Process for locating water flows has been used extensively in California for the past three years. It has recently been introduced in West Texas with satisfactory results.

It is a well known fact that in the majority of cases formation water entering a well is clear, solid matter having been filtered out by passage through the formation. The Dale process utilizes this property by producing a muddy column of fluid in the hole and measuring its translucency. Any thinning of the conditioning fluid by the entrance of the clear formation water is immediately detected by a photoelectric device.

The instrument itself (Fig. 9), consists of a source of light, B, separated from a photoelectric cell, C, by a circulation passage, A, through which the fluid in the hole is forced to pass. Any variation in the translucency of the fluid in the hole, therefore, will cause a variation in the amount of light received by the cell, C, which will be recorded by a meter situated at the surface.

The actual operation, therefore, consists in dumping a light mud in the hole and stringing it through the part to be surveyed. This is readily performed by a special dump bailer. The fluid level is then reduced until the water sources start giving up their fluid and water enters the hole. The part where the clear water is entering and diluting the muddy conditioning fluid is indicated by the meter at the surface, which records instantaneously the translucency and depth. Once the source has been passed the recorded curve drops to the normal reading for the conditioning fluid. Further reduction of the fluid level increases the translucency of the fluid in the well so that several runs can be made and the limits of the source of water found and confirmed. Fig. 10 (see page 92) shows three surveys made with this instrument in West Texas and the Mid-Continent.

At the present time this process is best applied to swabbing or pumping wells. With flowing wells that have to be killed it is not as easy. For in killing the well fluid, usually water, is forced back into the formation, irrespective of whether it is water-bearing or not. On lowering the fluid level these formations give back their injected water, thus giving rise to a false idea that they are water-bearing.

Conclusions

The foregoing will serve to show the application of electrical surveys to geological and engineering problems in West Texas. The examples shown, of course, are but a small fraction of those obtained in the three years work in this territory.

Electrical logs, as elsewhere, permit a perfect correlation between wells and an accurate differentiation of the type of formation encountered.

Temperature surveys serve to locate the gas in oil-bearing strata and hence permit a rapid and accurate means of determining the gas-oil contact. By this means the best casing seat can be determined in drilling wells and old wells with high gas-oil ratios can be reworked and their excessive gas production eliminated.

These surveys can also be carried out in wells filled with oil or in cable tool wells with no fluid. Under these circumstances very conclusive information about the pay section is given.

Waterflows in pumping wells can be accurately located by the Dale Photoelectric Process.

Acknowledgements

We wish to acknowledge the friendly and valuable coöperation of the Standard of Texas, Shell Petroleum Corporation, Humble Oil and Refining Company, Falcon Company, and others, through whose courtesy it has been possible to illustrate this paper with actual examples of field work.

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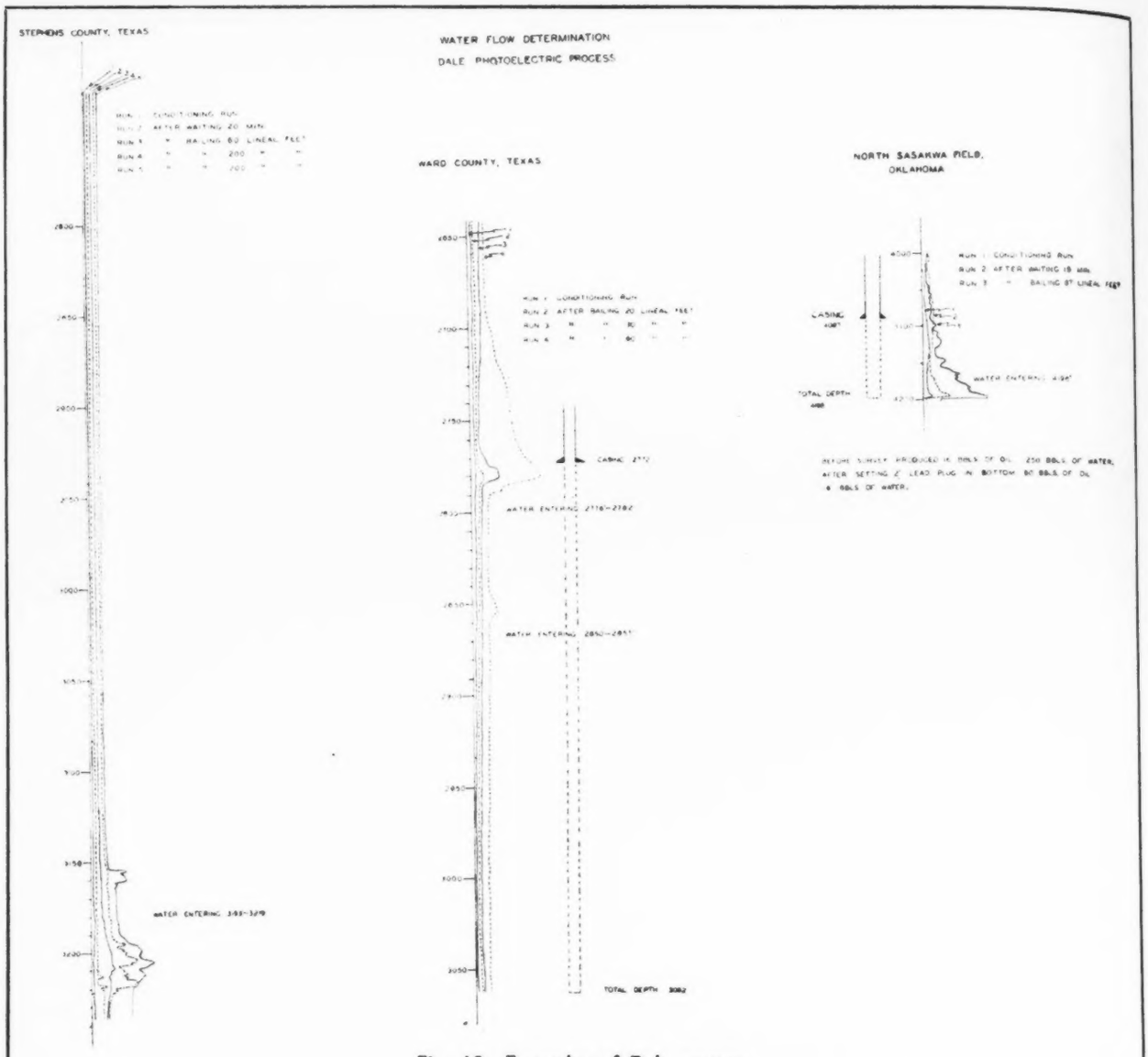

Fig. 10. Examples of Dale surveys

Dow to Make "Thiokol" at Midland, Michigan

A NOTABLE step in the advancement of the American synthetic rubber industry was taken on May 1st when a modern plant was officially opened at Midland, Michigan, for the production of "Thiokol" synthetic rubber. This plant, erected by the Dow Chemical Company, will be able to supply manufacturers with 2,000,000 lb. of the material annually. As synthetic rubber may be used separately or in combination with other materials, it is expected that the plant's output will result in the fabrication of more than 3000 tons of finished products.

Production of synthetic rubber in Europe has, according to reports, mounted to more than 15,000 tons annually. Germany, particularly, is bending every effort to make the country self-sufficient. How thoroughly the government has subsidized the industry is reflected in a recent remark by Goering that after munitions and airplanes, Germany is interested in the development of synthetic rubber.

In America, the progress of synthetic rubber has been steady rather than spectacular. In the last seven years manufacturers have found many uses for the man-made rubber that successfully resists the attacks of oils, etc. In particular, the oil industry is using synthetic rubber for parts such as gasoline-pump hose, paint-spray hose, fuel-oil hose, cargo hose, rotary-drill hose, oil-proof seals, clothing, gaskets, and roofing material.

The story back of the new plant has as much to do with geography as it has to do with needed business expansion. Practically all the raw materials that go into the making of "Thiokol" are manufactured by the Dow Chemical Company. Therefore, when the new construction was planned, it was felt expedient to build as near to the source of raw materials as possible. Situated on the Dow Chemical Company premises at Midland, Michigan, the present location and size of the new plant is a happy solution to every problem.

Thiokol Corporation of Trenton, New Jersey will concentrate its efforts on research, sales activities, and development of new products.

Three basic steps are involved in the manufacture of "Thiokol"; the manufacture of a polysulphide, the reaction between this polysulphide and ethylene dichloride to form a synthetic rubber latex, and the coagulation of this latex to form rubber crumbs.

Operators are becoming wire-line guide conscious

The above photo shows a shipment of thirty Patterson-Ballagh Guides—probably the largest shipment ever made at one time.

In slightly more than one year, this product has reached a popularity comparable to the acceptance given ten years ago to Patterson-Ballagh Casing Protectors.

Higher drilling speeds and taller derricks and heavier rope have made necessary the use of such a device to dampen the destructive whip and vibration in the line. This Guide is more than a spooler. It actually stabilizes the line and eliminates the hinging action that takes place in the line at the point where the line contacts the drum.

A prominent wire line official recently stated that this Guide actually adds at least 20 per cent to the life of the line.

Ask for free wall chart listing the 124 world's deepest wells

PATTERSON-BALLAGH WIRE LINE GUIDE

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Plant and General Offices: 1900 E. 65th Street, Los Angeles, California
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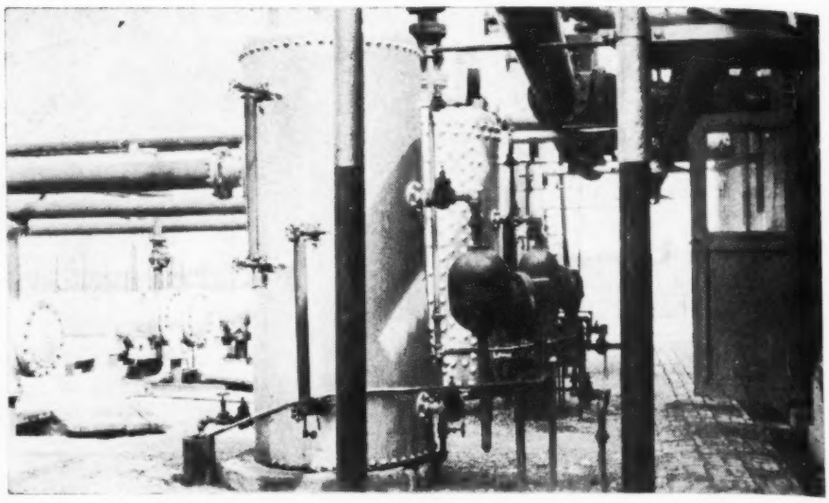
New York Offices: 39 Cortlandt Street, New York City

Hot-Water Baths on Control Instruments Prevent Freezing

By J. C. ALBRIGHT

ACCUMULATOR drums placed outdoors in the vapor-recovery unit at Pure Oil Company's Toledo refinery are equipped with liquid-level control on the outlet valves. These remote control instruments, exposed to cold winds, are fitted with hot-water baths so the gas or air controlling the pressure will be always free of ice.

Sheet iron boxes placed below the "kidney valve" are supported on pipe posts so that the remote-control device is below the rim of the box. Hot water from gas coolers and gasoline condensers is piped to these hot-water boxes through a header, the line to each individual box being equipped with a gate valve to control the flow of water to that box. The rate of flow is varied according to the atmospheric temperature. An overflow connection is provided near the top rim, and waste water drains from the boxes to the plant sewage system along with the water drained from the base of accumulator drums. It is stated that at this plant the hot-water warming boxes give satisfactory service even at the lowest temperatures experienced.



Hot-water baths for liquid-level controllers, used by Pure Oil Company in its vapor-recovery plant at Toledo, Ohio

Important Refinery Power Transmission Comparisons

By W. F. SCHAPHORST

TO demonstrate the differences in efficiency of power transmission that usually exist in refineries, the accompanying sketches have been prepared.

As shown in Fig. 1, the overall efficiency of a belt drive usually is 95 percent. By careful aligning, and by use of ball bearings, high-grade belts, etc.,

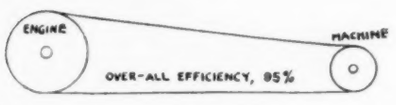


Fig. 1

efficiencies even higher than 95 percent are obtained, but that figure is used here because it is readily attainable.

Fig. 2 shows that when using four "re-drives," the efficiency of each being 95 percent, the overall efficiency (0.95 x 0.95 x 0.95 x 0.95) is 81 percent.

In other words, belt re-drives are a "bad thing." Keep the number of intermediate shafts to a minimum. "Intermediate shafts" are the shafts between the driving machine, whatever it may be, and the driven machine. The reason why re-drives are inefficient is clearly shown in Fig. 3. Thus, when the efficiency of the single drive is 90 percent, and when there are three in-

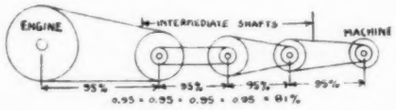


Fig. 2

termediate shafts, the overall efficiency drops from 90 percent to 65 percent, as shown by the top curve. The other curves illustrate what happens when the unit efficiencies are 80 percent, 70 percent, 60 percent, and 50 percent, respectively. Matters grow worse and worse. With a unit efficiency of 50 percent the overall efficiency, when there are three intermediate shafts, declines to 6 percent.

If 100 percent were possible, the overall efficiency, even with three intermediate shafts, would still be 100 percent. But perfect transmission, of

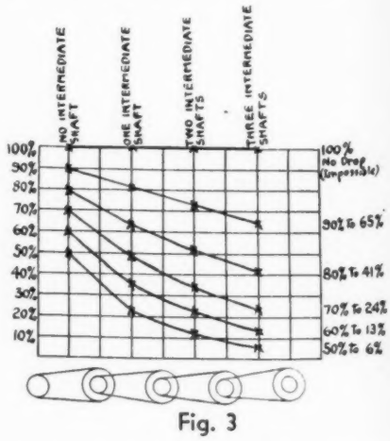


Fig. 3

course, is impossible. These sketches make it obvious that the efficiency of each unit drive should be kept as high as possible.

NO ALIBIS NEEDED

Tool joints lead a hard life, both on the derrick floor and in the hole. But that is never accepted as an alibi for poor performance.

Tool joints made from Chrome-Moly (S.A.E. 4140) steel never require alibis. They are tough and strong, and have good fatigue-strength. Their hardness keeps them from galling easily, and makes them resistant to abrasion and erosion. Chrome-Moly tool joints are just one example of how Molybdenum steels are saving time and money in oil production. Detailed information about them is given in our book, "Molybdenum in Steel," which will be sent on request. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

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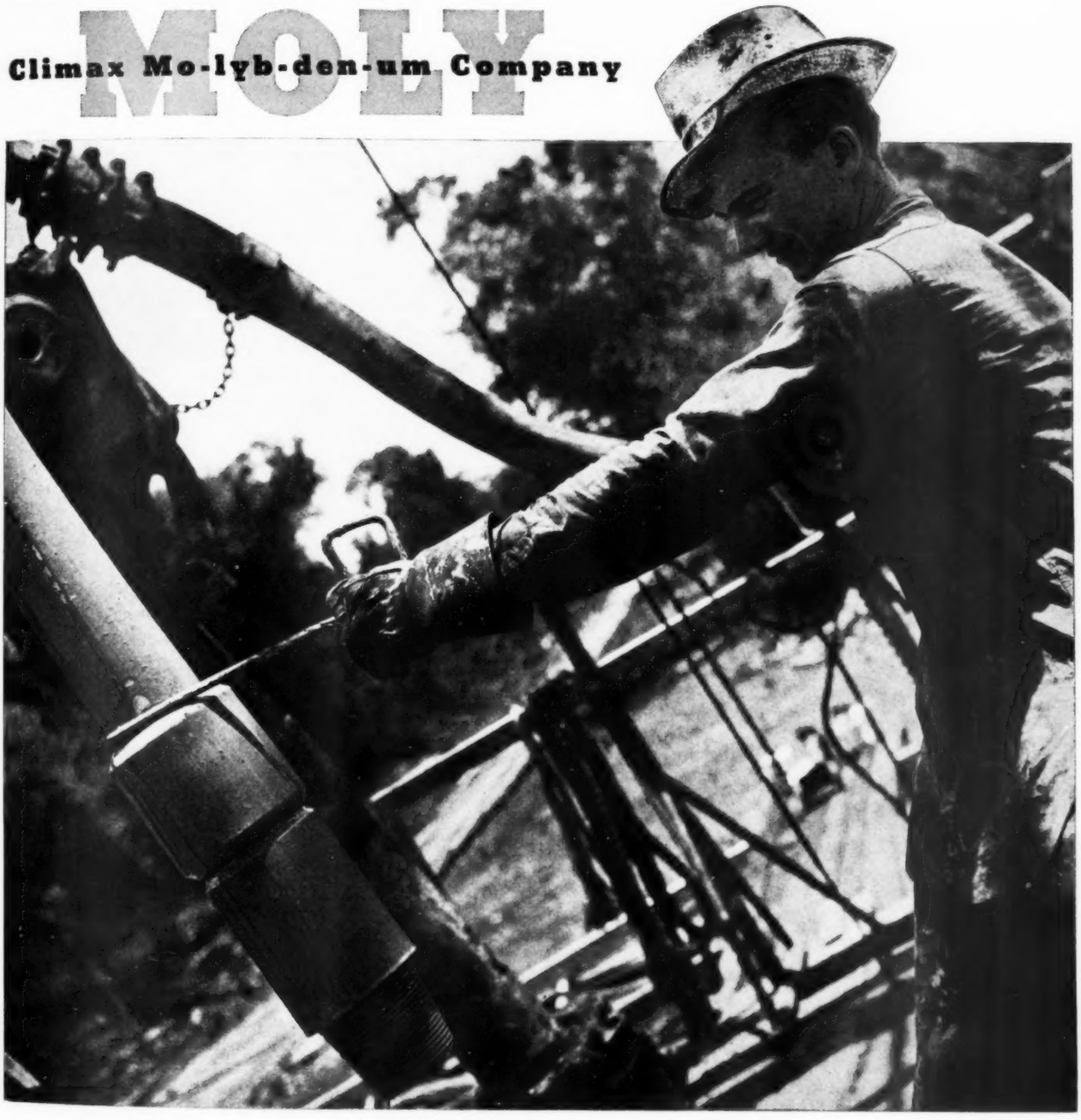

Running Tour
WITH MEN IN THE INDUSTRY

J. G. SPRATT, engineer at Calgary, Alberta, Canada, for the Petroleum and Natural Gas Division of the Alberta Department of Lands and Mines, resigned May 15th to accept a position as assistant manager of Anglo-Canadian Oil Company, Ltd.

ENRIQUE RODRIGUEZ-PERALTA, Tampico, Mexico, petroleum engineer with Huasteca Petroleum Company, has been transferred to the Lago Petroleum Company at Aruba, Netherlands West Indies.

ROBERT W. HARRISON has been transferred by the Continental Oil Company from the West Texas district, where he was petroleum engineer, to the Houston office of the company. His future activities will be on the Gulf Coast.

ELMER R. CORN, vice-president and general manager of the Plains Oil Company, has been named mayor of Wichita, Kansas, by the city commission.

J. O. MEAD, D. T. TURNER, and **LOUIS M. DANA,** of Parkersburg, West Virginia, have formed the Hazel Oil and Gas Company, having headquarters in the Grant district near Cairo, West Virginia.

RENE BERG, of Société René Berg, Paris, France, arrived in the United States on the Normandie May 2nd. He spent several days in New York before leaving for Tulsa, Oklahoma, to attend the International Petroleum Exposition as an official delegate for the Association Francaise des Techniciens du Pétrole.

H. P. GRIMM, independent operator, and at one time president of the Pacific Western Oil Company, has been elected president of the Bolsa Chica Oil Company, Los Angeles, California.

W. DUARD, New York City, with the Mexican-Sinclair Petroleum Corporation, is now in Venezuela, South America, supervising the drilling of a wildcat well by the Compania Consolidade Petroleo.

K. T. McCAMMAN has been promoted from production engineer at Shell Oil Company's Bakersfield, California, office to production foreman in the Ten Section field. **H. F. DANGBERG** has been transferred from Long Beach to assume his former duties.

CARL FISHER has been elected president of the Derby Oil and Refining Company, Wichita, Kansas. He was a member of the board of directors.

W. J. YOUNG, Tulsa, vice-president in charge of operations for the Oklahoma Natural Gas Company, has resigned to accept the post of president and director of the Northern Oklahoma Gas Company at Ponca City, Oklahoma.

J. R. HARMON, district superintendent for the Shell Oil Company at Oilfields, California, has been transferred to Bakersfield as district superintendent. **DONALD STEWART,** production foreman, becomes district superintendent at Oilfields.

E. H. CUNNINGHAM CRAIG, consulting petroleum geologist, left London, England, recently for Turkey, where he will be for three months doing research work for the Government Institution of Search and Investigation of Minerals.

K. S. ADAMS, executive vice-president of the Phillips Petroleum Company, has been elected president of the company, succeeding **FRANK PHILLIPS** who becomes chairman of the board. **C. P. DIMIT,** vice-president in charge of production; **A. M. HUGHES,** vice-president in charge of marketing; **F. E. RICE,** vice-president in charge of natural gasoline manufacture; and **M. P. YOUKER,** vice-president in charge of refining, all were elected directors of the company. **C. O. STARK,** in charge of the land department; **A. H. RINEY,** in charge of the engineering department; and **R. C. JOPLING,** in charge of public relations, have been made vice-presidents. **T. V. STEVENS** was elected assistant treasurer, and **J. F. KINSLOW** an assistant secretary.

GEORGE E. GODDARD, purchasing agent for the Cities Service Oil Company, Bartlesville, Oklahoma, has been made manager of the oil production division of the company to succeed **M. R. SHAFFER,** deceased. **HARRIS BATEMAN,** who has been Goddard's assistant, becomes purchasing agent.

LLOYD WILLIAMS, vice-president and general manager of the California Star Oil Company, was elected president of the Oil Producers Agency of California at the annual election recently.

VERNON L. RED has been made superintendent of the Northern Oklahoma District of the Magnolia Pipe Line Company, succeeding **G. V. COPLAND,** recently deceased. He formerly was foreman of the district. **HARRY F. SMITH** has been named superintendent of the North Texas District, succeeding **C. E. McGREW,** retired. Smith has been foreman of the Electra-Burk gathering system and main line.

SCOTT H. FARNUM, superintendent of the Yale Oil Refinery at Worland, Wyoming, was killed late in April when his car overturned on the highway east of Worland.

JAMES T. WOOD, JR., has been appointed assistant manager of The Texas Company (California) and has his headquarters in Los Angeles. He has been chief of the land and lease division of the producing company. **GEORGE R. COUPER** is the new chief of the latter division, of which he has been general assistant.

F. A. C. GUEPIN, who recently was appointed executive vice-president, has been elected to the directorate of the Shell Oil Company, S. Belither, president, has announced from San Francisco, California.

G. C. PARKER and **C. R. McVAY,** both of Tulsa, Oklahoma, have organized the Parker Drilling Company, headquarters being at 1214 Fair Building, Fort Worth, Texas.

The extra quality that is built into every detail of Parkersburg Pumping Units is your protection against excessive down time and maintenance costs. This finer engineering and construction will, in a short time, effect savings that more than offset the lower first cost that it's sacrifice would make possible. The truth of this has been discovered by operators all over the country.

Your Composite Catalog will give you details on Parkersburg Pumping Units . . . also the telephone number of the nearest Parkersburg representative. Call him today for complete specifications on the type you require.

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Leveling screws in base.

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Split hub cranks with set screws for spreading hub.

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"Banjo" Type Pitmans.

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Split Nuts on engine adjusting screws.

•

Adjustable saddle bearings.

LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

It doesn't make sense. Being poor is one of the hardest things in the world, and still one of the easiest.

* * *

"What did you do last summer?"
"I worked in Des Moines."
"Coal or iron?"

* * *

A "beautician" says women will be wearing topless bathing suits within three years. It would be novel to see them breasting the waves, and vice versa.

* * *

Emphasis Placed Wrong

Policeman (to motorist): Take it easy. Didn't you see that notice—"Slow Down Here?"

Motorist: Yes, officer, but I thought it was describing your village.—*The Yellow Strand.*

* * *

Oh, Papa!

Father: When I was a young man girls knew how to blush.

Daughter: What was it you used to say to them?

* * *

Two Broadwayites sat in a restaurant. At the end of the meal, one requested a loan.

"Can I borrow twenty bucks for a week?" he asked.

"Sure," replied the other counting out the money.

As they arose, the latter man spoke again.

"Remember," he reminded, "that's only for a week."

"You'll get your money," he screamed. "Stop hounding me!"

* * *

Pat was arrested for being intoxicated. On being brought before the judge, he was asked by the court what he was there for.

Pat: Your Honor, I was arrested for being intoxicated.

Judge: Pat, where did you buy the liquor?

Pat: Your Honor, I did not buy it. A Scotchman gave it to me.

Judge: Thirty days for perjury.

* * *

"Johnnie, did you want to leave the room?"

"Say, teacher, you don't think I'm standing here hitch-hiking, do you?"

One day a farmer went into the Albus Drug Store at Stayton and told Fred that his place was infested with ants. The farmer said he had tried ant-paste and powder, with no good results, and he wanted to know if Fred had anything else that would help to rid his place of the pests. "Have you tried the new formula, WPA, on 'em?" "Will that kill 'em?" asked the man. "Well," said Fred, "if it don't, it will make 'em so damned lazy you can step on 'em."—*New Canaan, Conn., Advertiser.*

* * *

A little colored boy was sitting slumped down in his chair with his feet resting on the table when his Mammy came in and said: "Lawd, you is a lazy boy; you zackly like yo' pappy. Thank de Lawd I didn't marry dat man!"

* * *

When the festivities were at their height, Charlie, who was best man at the knotting, decided to tell about a trick he'd played on the groom the day of the wedding.

Turning to the happy couple, he said, "I'll bet you were mad when you discovered that I had taken all of Harry's pajamas out of his suitcase."

The bride and groom looked up at each other blankly and then looked up at Charlie.

"My gosh, did you?" gasped the bride.

* * *

"I gave my wife a half-dollar to go out and get a knick-knack—and whutta you think?—she came back with a tid-bit."

* * *

Adam went to Heaven and became dissatisfied, so asked St. Peter to allow him to pay a little visit on earth."

"No," said St. Peter, "You raised enough cain while you were down there."

Then Adam said, "Please let me go back for a little while—I want to turn over a new leaf."

* * *

At Least the Book was Good

A mother was recently disturbed over the two-day absence of her daughter, but everything was all right when the girl returned with a Gideon Bible under her arm.

We'd say here was a perfect maid.

During the day Mrs. Brown discharged her old maid and hired a new one, who answered the door bell when Mr. Brown arrived home in the evening. He carried a bunch of roses, which he handed to the maid, saying:

"Present these to Mrs. Brown, telling her I want to see her at once."

"All right," said the maid, "but you better make it snappy, because she expects the old man any minute now."

* * *

A little girl had three dogs. She called one of them "Fluffy," because it was the fluffiest dog in town. She called another "Curley," because it was the curliest dog in town; and the other she called "Paderewski," because it was the pianist dog in town!

* * *

"Last night I was kissed twenty times in twenty minutes."

"By the same man?"

"No. He was a changed man after the first kiss."

* * *

"Mamma," said little Dorothy, "sister don't tell the truth."

"Why, Dorothy, you mustn't say such things," reproved the mother.

"Well, last night I heard her say, 'Charlie, if you do that again, I'll call mamma.' And he did it twice more and she didn't call."

* * *

Speaker: My friend, I think that our President is the greatest man this country has seen.

Farmer: I am agin him, too.

Speaker: Don't you know that behind every man there is a supreme power which controls and influences him?

Farmer: I am agin her, too.

* * *

Wife: Dear, I've set my heart on a Rolls Royce.

Hubby: Yes? Well, that's the only part of your anatomy that'll ever set on one.

* * *

Mirandy, surrounded by her brood of pickanninnies, was talking to the spinster settlement worker, "Yas'm, birth control am all right for youall but me, Ah's married an' doan need it."

Stabbed at midnight!

★Youngstown Casing or Drill Pipe can be run as easily and quickly at midnight as at noon--because threads are always accurate, clean and uniform.

Youngstown has special engineers who spend *all their time studying conditions in the oil fields.* They know how important it is to save you time and trouble. They know how important it is to furnish pipe you can depend on to work WITH you instead of against you. That's why Youngstown checks thread details so closely.

Youngstown makes each length of tubular goods carefully realizing its reputation for uniform good quality depends on that joint. The result is you can buy Youngstown with the comfortable assurance that it will be easier and faster to run, will last longer and will SAVE YOU MONEY.

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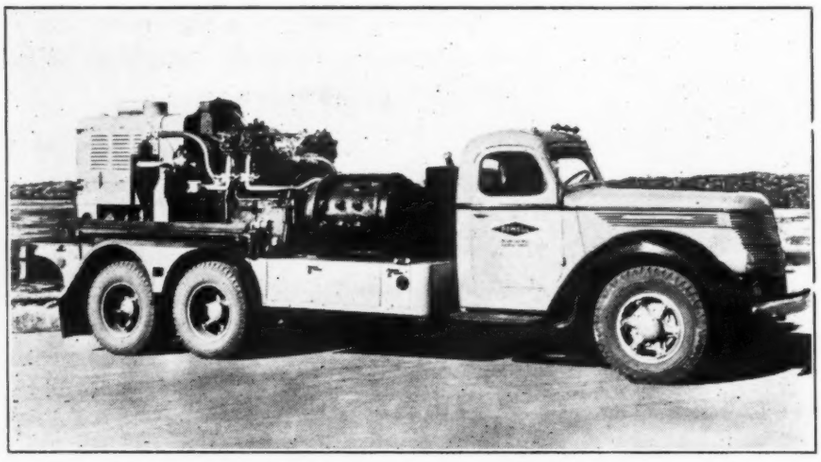
YOUNGSTOWN

MACHINERY and EQUIPMENT

Dowell Compressor Unit for Treating Gas Wells

THE new Dowell compressor unit for chemical treating of gas wells, manufactured by Dowell Incorporated, Midland, Michigan, is an especially-designed unit mounted on an International D-246 F six-wheel chassis that weighs, loaded, about 27,000 pounds. The mounted equipment consists of a Dowell acid pump, Hendrickson split shaft take-off, special built Dowell gas compressor, International auxiliary power unit, and Tulsa underslung winch.



The pump is a special Dowell design capable of pressures to 3000 lb., and delivery of 180 bbl. per hour at lower pressures. The power case is Dowmetal, a magnesium alloy, which reduces the weight of the pump about 4000 lb. compared with cast-iron construction, the makers state. The liquid end is a special steel and bronze construction. The Hendrickson split shaft power take-off is used to drive the pump under full load using the truck engine only and to drive the compressor using both the truck motor and auxiliary power unit. The two motors are synchronized, using tachometers and special control mechanism so both will pull evenly under load. The pump and compressor drive control mechanism is arranged for the operator's convenience and is fully enclosed to protect it against dust and for safety.

The special compressor is a 4-cylinder, V-type with a Dowmetal crankcase to reduce weight. Force-feed lubrication is applied to all moving parts, and a separate lubrication system is provided for the upper cylinder and valves to eliminate sticking and excessive wear due to handling gas. The machine may be operated either single or two stage by opening or closing valves in the manifold piping. Cylinders and heads are removable and interchangeable for different pressure conditions in different fields. An automotive cooling system is provided with a belt-driven fan and pump driven from the compressor crankshaft. The radiator is the conventional automotive type. The piping is high-pressure seamless tubing having flanged, screwed, and welded joints. A separator is in the suction side. Pop valves are provided as safety measures. An instrument panel is provided to carry the differential flow meter, temperature and pressure gauges, also the tachometer for synchronizing the motor. A lighting system is provided to illuminate the instrument panel and the entire unit at night.

An underslung winch is mounted under the compressor and an outrigger, sheaves, and snatch blocks are so arranged that pull from either front, rear, or side can be effected. The winch is driven by a separate take-off mounted on the side of the truck transmission.

The truck is equipped with first-aid kit, two fire extinguishers, fire blanket, flares, flags, shovel, and complete assortment of tools arranged conveniently in tool boxes on either side of the unit. The color scheme is standard Dowell orange and black.

American "Simplomatic" Cathead

THE American "Simplomatic" Cathead is the newest product to be offered by the American Iron and Machine Works Company of Oklahoma City, Oklahoma, and Houston, Texas. Although this new cathead has proved it will perform perfectly on any type of drawworks, it is specially adapted for use on drawworks having a fast line shaft, claim the manufacturers.

The "Simplomatic" is said to be

built of the finest materials available to withstand strain far in excess of that to which the cathead may be subjected, and is so designed that all metallic shocks or jars have been practically eliminated by lightening the engaging member to which the jerk line is attached.

Once the cathead is installed, it can be completely dismantled and worn parts replaced or repaired at the rig by the drilling crew, add the manufacturers. The cathead can be dismantled without removing the spool from the line shaft, effecting a saving in time and cost of repairs.

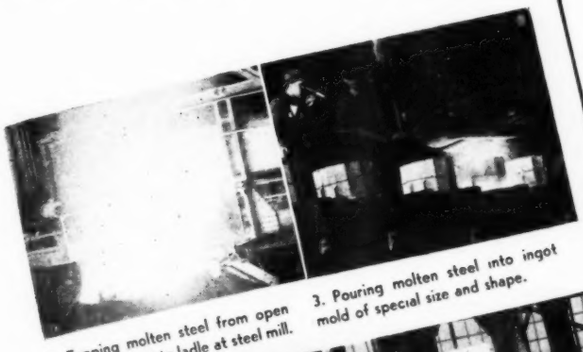
1. Charging pig iron and steel scrap in open hearth furnaces at steel mill.

TRACING the LIFE LINE

of AXELSON SUCKER RODS FROM PIG IRON TO FINISHED PRODUCT

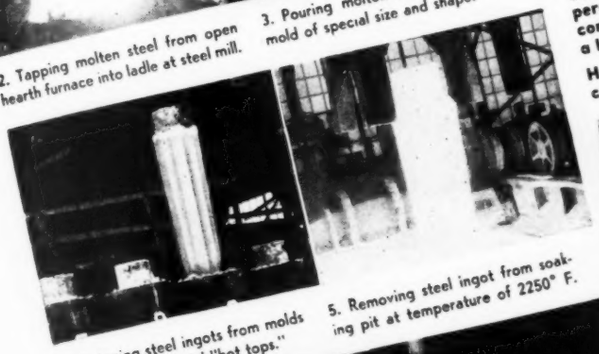
Nothing is ordinary in the manufacture of Axelson Sucker Rods. From the very beginning at the steel mill, everything is special. Smaller open hearth furnaces and smaller ingot molds of special shape are used. Longer time is required—more passes through the rolls—heavier cropping of ingots, blooms, billets and bars—are specified. Chemical composition, including nine or more elements, is regulated to the hundredth of one percent. Progressive tests and analyses are made and recorded, and if any test is not completely satisfactory, Axelson exercises the right to reject the entire heat—perhaps a hundred tons of good steel, but steel that is not good enough for Axelson.

Here are a few of many reasons why Axelson Sucker Rods reduce "down" time and cut "up" expense in the wells of the oil world.



2. Tapping molten steel from open hearth furnace into ladle at steel mill.

3. Pouring molten steel into ingot mold of special size and shape.



4. Stripping steel ingots from molds provided with special "hot tops."

5. Removing steel ingot from soaking pit at temperature of 2250° F.

6. First pass of steel ingot through blooming mill rolls.

7. Stamping identification of heat numbers on steel bloom.

8. Chipping, cleaning and inspecting steel billets.

9. Billet mill with various accurate controls.

10. Steel billet on the way to be sheared to proper length.

11. Square billets being reduced to the proper diameters for Sucker Rods.

12. Bars laid out on the "Hot Bed" to cool.

13. Sucker Rod bars being sheared to length.

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

AXELSON

DEEP WELL PLUNGER PUMPS

SUCKER RODS

Axelson Manufacturing Company, P. O. Box 98, Vernon Station, Los Angeles • St. Louis • 50 Church Street, New York • Tulsa

Mid-Continent and Eastern Distributor: Frick-Reid Supply Corporation • *Rocky Mountain Distributor:* Great Northern Tool & Supply Company.

Slush Pump Piston

THE Wells Convertible Slush Pump Piston is now being manufactured and distributed exclusively by the W-K-M Company, Inc., Houston, Texas. This piston is quickly converted from

one size to another by merely changing the rubber sleeves. This feature eliminates the necessity of frequent pulling of the pistons from the rods, and also enables several changes of size at the cost of only the rubber sleeves. Steel parts are of top-grade, heat-treated steel. The steel insert ring, vulcanized to the laminated rubber sleeve, absorbs all the load and insures longer life, the manufacturers state.

Unibolt Tee

THORNHILL-CRAVER Company, Inc., Houston, Texas, manufacturers of Unibolt couplings, recently placed on the market a 6000-lb. test pressure cast-steel Tee that, because it embodies the Unibolt coupling principle, has several features that the makers claim have never before been available in a similar fitting.

According to the manufacturer, the Unibolt Tee is particularly suited for use on high-pressure Christmas tree manifolds inasmuch as it obviates the need of the conventional threaded bull plug. It is equipped with a blanking plug that, as its name implies, serves the same purpose as a bull plug but is said to provide greater safety. The blanking plug may be removed and re-installed indefinitely for the purpose of changing flow beans without danger of leaking as a result of repeated removal, it is stated.

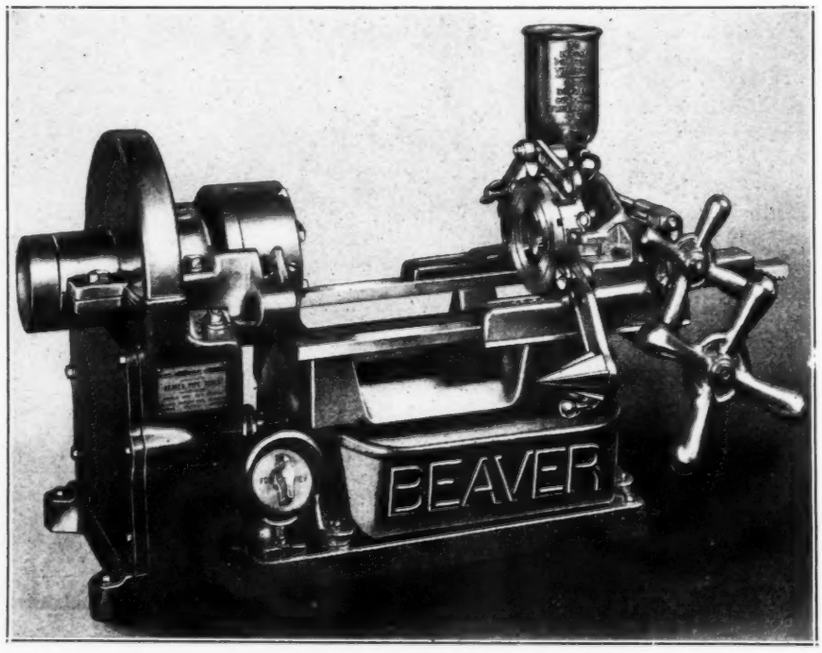
In addition to being safe under pressure, the Unibolt Tee is claimed to provide the quickest connection available, and because its parts interchange with those of the regular high-pressure steel Unibolt coupling, it would be particularly advantageous in event it became necessary to kill the well, it is pointed out.

Tapered shelves, or holding members, are cast integral with the Tee body, which are engaged by identical shelves in the nut member to effect a seal, the interlocking shelves being drawn together by a single bolt. The blanking plug and Tee body are grooved to accommodate a metal seal ring as in the high-pressure steel Unibolt coupling. The blanking plug is available either tapped or solid, tapped blanking plugs being supplied with a threaded plug that may be removed to accommodate a pressure gauge if desired.

Fully descriptive literature will be sent on request.

The Beaver Model B

BEAVER PIPE TOOLS, INC., Warren, Ohio, have announced the Beaver Model-B, a full range ⅛-in.



to 2-in. portable pipe and bolt machine, which may be purchased complete or in units. The Model-B is a simplified version of the larger and more expensive Model-A. Right handed, like a lathe, it cuts, threads, and reams nine sizes of pipe from ⅛ in. to 2 inches. With a drive shift and geared tools, it will cut and thread 2½-in. to 12-in. pipe. It will cut off solid bolt rounds up to 1 in.; 2-in. bolts may be threaded in one cut. It is all-gear driven—no belts; is equipped with standard all-steel geared chuck and an automatic chuck wrench ejector, an invaluable safety feature. The Model-B is self-cleaning, chips and oil fall, by gravity, into removable trays on either side of the machine. A trouble-free reservoir provides an adequate bath of flowing oil to dies.

For those who look forward to the day when they can own a complete ⅛-in. to 2-in. pipe and bolt machine, but who prefer not to incur all of this expense at one time, it is announced that the Beaver Model-B may be purchased gradually, in units, starting with the simple Model-B power drive. The power drive can be used to operate all makes of hand pipe threaders, cutters, and reamers for fabricating pipe from ⅛ to 2 inches.

B-J Submersible Pump

AFTER eight years of successful performance under a wide range of operating conditions, the Submersible deepwell turbine pump has been placed on the market by Byron Jackson Company, Los Angeles, California.

This marked departure from the customary type of deepwell turbine pump has its motor below, and not above, the turbine bowls. The propelling shaft is very short and the unusually-long, small-diameter motor operates submerged at all times in the well water. The liquid pumped, however, does not come in contact with the electrical parts or motor bearings, as these are enclosed in an oil-filled case with a mercury seal where the shaft passes through at the top. The turbine and the submersible motor form a compact unit that is attached to and supported by the discharge pipe. A submarine armored cable and a small copper oil tube form the only connection (aside from the discharge pipe) between the pumping unit and the surface of the ground. The Submersible pump operates equally well and without frequent attention in deep or shallow wells, crooked or straight wells, sumps or natural bodies of water.

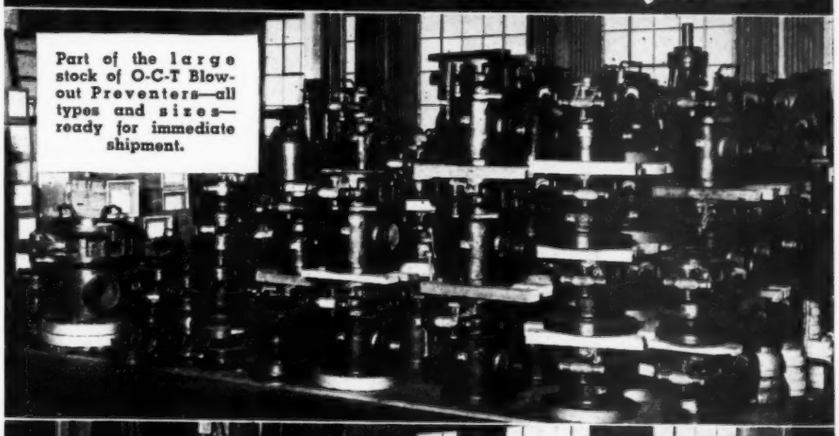
This new unit embodies many engineering features that are new to the turbine pump industry, the manufacturers state. The motor is a squirrel-cage induction type and its rotor is carried on two ball bearings, one of which is a radial thrust to take both the small weight of the rotary parts, and the hydraulic load. The other ball bearing is of radial type, and its chief function is to center the rotor. A high dielectric oil is circulated through the entire windings at all times and, although the small copper tube affords a means for replenishing the oil supply, motors have operated continuously for several years without adding to or changing the oil supply.

Water is sealed out at the top by mercury in a rotating cup that is attached to the motor shaft. A cylindrical sleeve is placed around the motor shaft, with one end attached to the motor casing and the other end submerged in the mercury. Thus the water and the motor oil are sealed off on their respective sides.

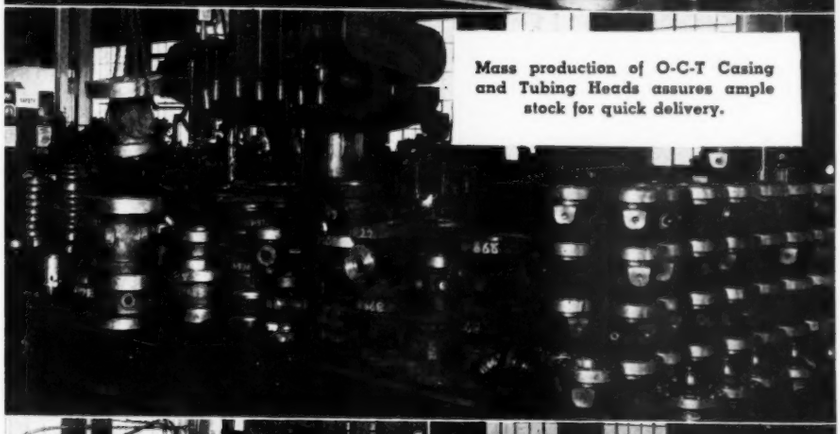
As the first unit was put in service in February, 1929, there have been some 12,000 hp. of Submersible units installed. The first pump, set 450 ft., in a well and powered by a 50-hp. motor, still delivers its rated 250 gal. per min. against a 475-ft. head.

Complete information (including a large cross-section drawing) can be obtained by addressing Byron Jackson Company, Dept. 114, Los Angeles.

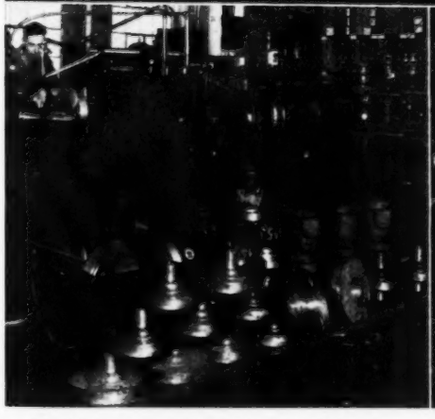
O-C-T NOW OFFERS
Quickest Delivery
ON HIGH PRESSURE WELL EQUIPMENT



Part of the large stock of O-C-T Blow-out Preventers—all types and sizes—ready for immediate shipment.



Mass production of O-C-T Casing and Tubing Heads assures ample stock for quick delivery.



Machining tops and bodies for O-C-T Casing and Tubing Heads on a heavy-duty turret lathe.

Finished bodies . . . ready to be assembled into complete O-C-T Tubing Heads.

OIL CENTER TOOL CO.
O·C·T
HOUSTON, TEXAS, U.S.A.
CABLE ADDRESS "OCENTOL"

Vari-Pitch Speed Changer

THE Texrope Division, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, has placed on the market a new speed changer unit said to open up new horizons in variable-speed transmission. It utilizes the already well-known principle of that company's multi-groove vari-pitch sheaves. The new speed changer consists of a ruggedly-constructed, compact unit applicable to all manner of industry. This totally-enclosed unit, designed with double-shaft extensions and driven from a standard motor, provides the flexibility that makes it adaptable to a wide variety of layouts to suit the individual application. Where the change in speed is to be adjusted manually only, the unit is provided with a readily-accessible handwheel control; however, the unit can be equipped for electric remote control. Manual remote control is also possible. The present range of capacities now being offered includes ratings to 33 hp. with ratios as high as 3¾ to 1. It is expected that larger ratings may be developed in the future.

The new Allis-Chalmers Speed Changer Unit has been designed to fill the need for equipment in any industry where a substantial change in speed is desirable to better control production. It is especially applicable where material-handling equipment must be controlled. Exhibition units

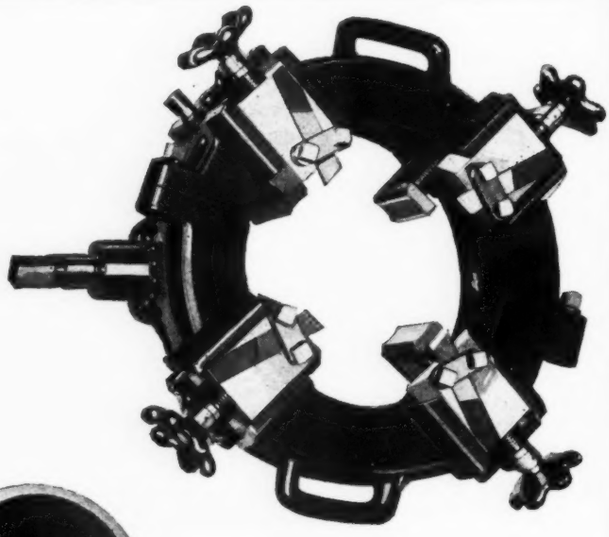
are being shown at the principal national trade expositions. Descriptive bulletin 1266 may be obtained from the company's nearest district office.

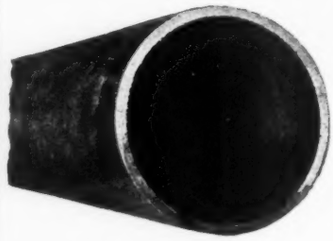
Portable Drilling Rig

THE International Derrick and Equipment Company, Columbus, Ohio, recently placed a new portable drilling machine on the market that

is a complete and self-contained unit.

This machine is unusually flexible, and is easily adaptable to its many uses in oil-field operations, the manufacturer states. It may be used for combination rotary and cable-tool drilling, heavy straight cable-tool drilling, drill-





Straight, square end cuts without burr.

Pipe is quickly and neatly beveled with special blades.

"Toledo" Geared Pipe Cutters

—cut off large pipe quickly, accurately and leave a straight square end cut without burr.

May be split apart and clamped around pipe already in line and the pipe cut off without bother of taking it down.

Knives are hand-fed, given a part turn as cutter frame revolves. Knives are double ended and are high speed steel.

Four models from 2½ to 12-inch. Specify a "TOLEDO" Geared Cutter for good results.

THE TOLEDO PIPE THREADING MACHINE COMPANY
TOLEDO, OHIO NEW YORK OFFICE, 72 LAFAYETTE STREET

"TOLEDO"
TRADE-MARK REGISTERED

BE SATISFIED *SPECIFY "TOLEDO"*

ing-in service, clean-out service, and potential pumping service.

This portable rig may be steam driven, in which case the engine is placed between the crank shaft and the samson post, or it may be driven with a multi-cylinder gas or Diesel engine by inserting a reversing jack shaft between the prime mover and the crank shaft. The Ideco Type "F" reversing jack shaft is built especially for this application.

The Ideco Portable Rig may be equipped with a two-speed Ideco drawworks for drilling with rotary tools through the drift. The rig may then be standardized quickly for cable-tool hoist, samson post, walking beam, and pitman.

Cooper-Bessemer Announce New 40-50-hp. Compressor

MAKING its initial public appearance at the Petroleum Exposition at Tulsa is the new Cooper-Bessemer Type G-MS Compressor Unit. Rated 40 to 50 hp. at conservative speeds, this addition to the company's complete line of gas and Diesel engines and compressors is a combination of the well-known Type G-SD vertical pumping engine and a vertical compressor cylinder.

Merged with all the attributes of the G-SD vertical engine are the advantages of a 40- to 50-hp. compressor that requires less than half the space of its horizontal predecessors, retains all of their slow-speed, long-life qualities, and effects economies from first cost to actual operating and maintenance expense, the manufacturers state.

Designed for delivering gas into high-pressure lines, compressing air and refrigeration gases, repressuring oil sands, and for natural gasoline extraction in small plants, the Type G-MS compressor is light in weight, rugged, and extremely compact. Easily transported, requiring a minimum amount of floor space and housing, and convertible for oil or gas fuel, the compressor can be arranged for two-stage operation through the addition of a second compressor cylinder mounted horizontally on either side of the compressor base.

The engine is a crosshead type having tapered roller bearings for its main shaft and is fully pressure lubricated. Its crankpin bearings are precision removable shells and wrist pins are the patented "T" type, providing greater bearing surfaces than is usual in this type of engine, according to the makers. Crosshead pin bearings are removable bronze bushings.

The vertical compressor, bolted to the drive end of a standard G-SD engine and using the same bolt circle provided for the engine clutch housing, becomes an integral part of the power unit, its husky crankshaft supported at the outer end by a radial-type roller bearing. The single-acting compressor cylinders can be arranged for either single-or two-stage compression, by using a vertical and horizontal combination. The compressor lubricating system, entirely independent of the engine's system, has built-in lube-oil filter with the compressor base acting as a sump. Its water-cooling system is in parallel with that of the engine, a single safety device guarding both against low water supply. Compressor connecting rods are identical with those of the engine and piston pins float in removable bearings. The vertical compressor cylinders are available in sizes six to nine inches. Horizontal cylinders for two-stage operation may be used in any size within the engine's hp. rating.

Built-in centrifugal water pump, heavy-duty roller bearings, advanced-type crossheads, and all iron castings of Meehanite Metal are other features of this new Cooper-Bessemer compressor unit.

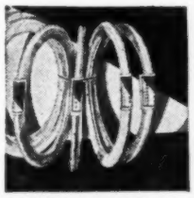
THE RIGHT PACKING in the Right Place!

J-M Sea Rings. Absolutely automatic. Save power. Reduce wear on equipment. Last longer.

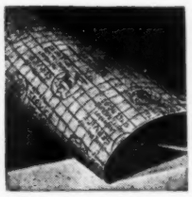
J-M Kearsarge Rod Packing. Retains its efficiency—note construction of center block.

J-M Centripac. Plaited construction. Specially designed for centrifugal service.

J-M Flax Packings available in various styles to meet a wide variety of service conditions.



J-M Kearsarge Boiler Gaskets assure a perfect seal on handholes, manholes and tube plates.



J-M Service Sheet. Pliable. Resilient. Adaptable to all general sheet packing purposes.

J-M Mogul Packing. An excellent utility packing for general service.

FOR *complete* information on J-M's *complete* line of packings for the oil industry, send for the J-M Packings Catalog. Address Johns-Manville, 22 East 40th St., New York City.

Johns-Manville PACKINGS

For Every Oil Industry Service

JOHNS MANVILLE JM PRODUCTS

Vertical Drilling Engine

A NEW vertical piston-valve roller-bearing heavy-duty steam drilling engine, said to possess many exclusive design features, has been announced by the Ajax Iron Works. The new Ideal-Ajax is built in the popular 9 by 8 size, as well as 7 by 8, 8 by 8, and 9½ by 8 sizes, for 350-lb. working steam pressure.

The engines have a force-feed cylinder lubrication and a combination force-feed and splash engine lubricating system; anti-friction bearings in crosshead; heavy 6½-in. diameter double-throw, counter-balanced forged-steel crank shaft, which is supported in two double-row tapered roller bearings; interchangeable cylinder blocks; and many other features.

The Ideal-Ajax Vertical Engine, the manufacturers state, is built for those desiring a rugged, reliable, heavy-duty, economical prime mover for use where floor space is limited. Several of the numerous applications of these engines on a rotary rig include: Direct drive to rotary machine; dual drive to slush pump, rotary machine and drawworks; direct drive to slush pump by means of V-belts or chain.

Recently-completed tests are said to show that an Ideal-Ajax Steam Engine driving a slush pump operates with a steam consumption as low as 28½ lb. per indicated horsepower.

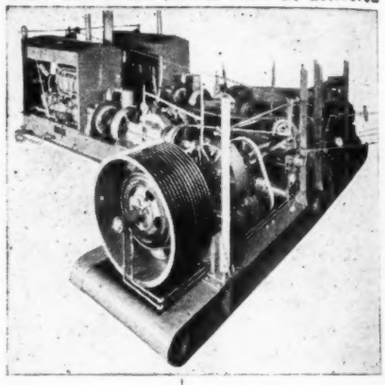
In addition to economy in steam consumption and lubricating costs, a hand-controlled variable cut-off valve gear, high safe operating speeds, and wide flexibility of application are a few of the outstanding advantages, it is stated.

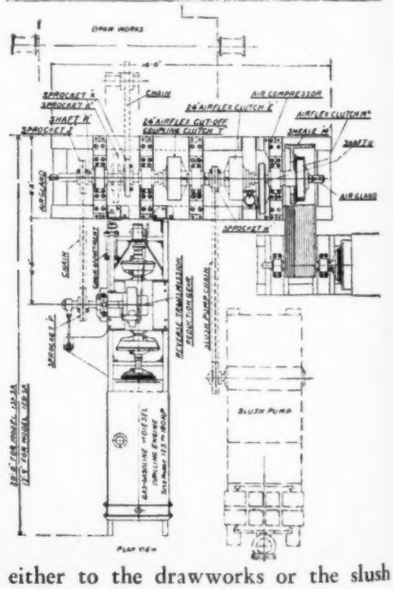
Full details are available by request from the manufacturer, Ajax Iron Works, Corry, Pennsylvania, or any National Supply Co. representative.

Universal Jack-Shaft

Flexible use of power is one of the important features of the newly-developed Universal Jack-Shaft of the Young Engine Corporation, Canton, Ohio. With this equipment the drilling engine, while drilling, provides power to the rotary table through the jack-shaft while the power unit drives the slush pump.

When handling the pipe, the engines may be compounded by engaging the Airflex Cut-Off Coupling Clutch and their combined power may be delivered either to the drawworks or the slush pump.





When additional power is required a third engine may be installed.

THE SCIENTIFIC SOLUTION TO BRAKE RELINING PROBLEMS
A BEAR FOR WEAR
GRIZZLY
ROTARY BRAKE BLOCK
BAND EXCHANGE
When your rotary brakes become worn, and bands get warped or out-of-round, don't worry and waste time on a field relining job. Simply turn in your old bands on the Grizzly Brake Block Band Exchange plan, and receive brand new steel bands, made exactly to factory specifications for your particular draw works, and factory lined with genuine Grizzly Full-Moulded Rotary Brake Blocks of the correct thickness, width, length and radius.
This is the quick, scientifically accurate method to reline rotary brakes, and the cost is no greater than ordinary lining and installation.
New Grizzly steel bands for all types of rotary draw works are stocked by leading supply houses and at Grizzly warehouses. Ask your supply man for details.
E. M. SMITH COMPANY
600-650 South Clarence Street • Los Angeles, California, U. S. A.
Complete Stocks Maintained In Our Warehouses At: 2311 West St., Houston, Texas. 1008 S.E. 29th St., Oklahoma City, Oklahoma. Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York City.
Distributed by Leading Supply Companies

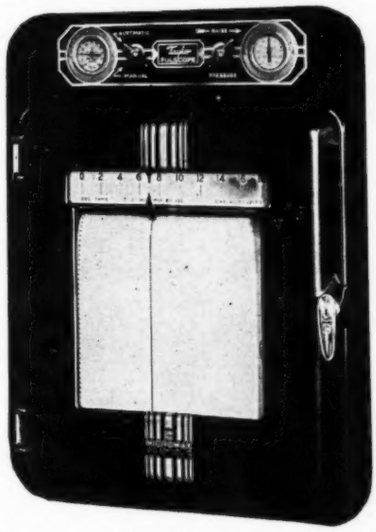
Side Link Bail Casing Hook

A CAST alloy-steel spring casing hook having side link bail for 200- and 300-ton service has been developed by Regan Forge and Engineering Company of San Pedro, California. It is cast from SAE 4140 steel and heat treated, and tested for loads in excess of rated capacity. A removable side link becket permits the assembling of the hook and traveling block with ease, especially with the older types of traveling blocks having single-piece forged beckets. The side links are of well-proportioned I-sections, cast of nickel-vanadium steel, as is the swivel block.

Manual By-Pass on Taylor Controller

TO the Taylor Fulscope Micromax Controller, manufactured by the Taylor Instrument Companies, Rochester, New York, has been added a new feature, the Manual By-Pass.

It is particularly desirable on some applications to start the apparatus on hand control and "cut in" automatic control as the operating temperature is reached. When hand operation is required, the Manual By-Pass enables the operator to change the controlling-medium input at the instrument where its effects are recorded. Furthermore, it permits adjustments or repairs to the instrument without unduly disturbing the heat balance in the apparatus, it is stated.



Change-over from manual to automatic control, or vice versa, is simple. When the left adjusting knob on the instrument sub-panel is turned to the arrow marked "Automatic," a 4-way air valve on the back of the panel connects the air supply to the Fulscope control mechanism. When the knob is turned to the arrow marked "Manual," the 4-way valve connects the air supply directly to the diaphragm valve (or Dubl-Response Control Unit, as the case may be), by-passing the Fulscope mechanism. Stops limit the turning of the knob.

The right adjusting knob regulates the air supply pressure, being connected directly to a dependable air-reducing valve on the back of the panel. When on automatic control the air supply is maintained at 25 pounds. Before changing over from automatic to manual control, the output air pressure to the diaphragm valve is observed (left air gauge) and the air supply (right air gauge) is reduced to that value. Thus, when the Fulscope mechanism is by-passed, the control point is maintained. During manual operation, control point adjustments and compensation for changes in load are made by reducing the air supply pressure and observing the control record.

THE NEW
MARTIN-DECKER
measuring line
WEIGHT
INDICATOR
You need this new Martin-Decker Measuring Line Weight Indicator on your line hoist. You'll find it an invaluable aid when running instruments or tools on measuring lines . . . for locating cement plugs *accurately* . . . and for controlling torpedo lines and insulated shooting lines.
This new Martin-Decker Measuring Line Weight Indicator has been improved in every detail. It is more sensitive, more accurate, more rugged. Parts have been cut to an absolute minimum, weight has been decreased and performance has been improved through new mechanical features. Let us send you the circular describing all the performance features of this improved instrument!
MARTIN-DECKER CORPORATION
LONG BEACH CALIFORNIA
San Joaquin Valley: A. F. McQUISTON, Bakersfield, California
Mid-Continent Distributor: REED ROLLER BIT COMPANY, Houston, Texas

Metric Air-Actuated Remote Recorder

ENGINEERS of Metric Metal Works, Erie, Pennsylvania, of American Meter Company, announce completion of field installation tests on their new "Metric" Air-Actuated Remote Recorder.

Now formally listed among Metric-American products, this remote recorder accurately charts—at a point remote from meter installation — the volume of gas, air, steam, or fluid measured by orifice method, it is stated. The device consists of sending, receiving, and control apparatus, and the control mechanism may be installed in either the sending or receiving unit case.

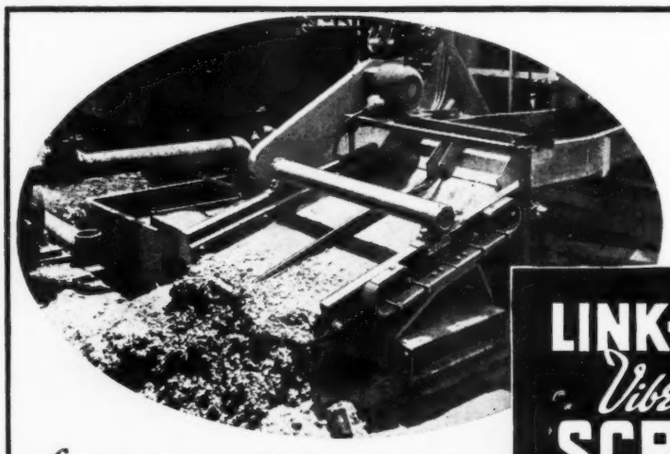
(This same principle of remote transmission may be utilized in connection with zero to 100 percent throttling, in the control of rate-volume, or for automatic reset control.)

Position of differential pen arm in the sending unit of the remote recorder is at all times duplicated in the receiving unit by the position of the differential pen arm that makes the chart record, and there is little lag in synchronization. Sending and receiving units are connected by 3/16-in. copper tubing. To place the remote recorder in service, it is necessary only to set the differential pen arm at zero on the chart, and to open an air-line valve and adjust a pressure-reducing valve. Operation is positive. The valve in the air line, connected at S (see illustration), is opened; and the pressure-reducing valve in the sending instrument is adjusted so that 35 lb. is shown on gauge R. Differential pen arm 6 in the receiving instrument will leave the chart hub and come to rest at zero (if necessary, adjust to zero with micrometer on pen arm).

A forged-steel Westcott orifice meter differential gauge in the sending instrument actuates differential pen arm A and lever B. Pen arm A indicates on Scale U the differential across the orifice plate at each instant. Lever B, through link K and lever H, moves the valve of a standard Metric rotary pilot (C), consisting essentially of housing sleeve, rotary seat, and rotary valve. Air supply for pilot valve C is connected at S. Gauge R, indicating pressure available, is connected to pilot valve C by line Q. The outlet of pilot valve C is line P, which is connected to sylphon N, and at point T is connected to the receiving instrument.

If differential pen arm A is moved in a clockwise direction, lever H moves the valve of pilot C, increasing pressure in outlet pipe P. Line P extends through spring O and is connected to sylphon N at bracket N′. Pressure increase in line P causes spring-loaded sylphon N to expand, M′ and O′ to rise, and spring O then to be compressed. Link M moves lever G (pivoted at L) clockwise, and this movement through link F, adjustment E, and lever D, moves clockwise the seat of the pilot.

It is seen that the valve of the Metric Pilot is moved by the differential pen arm, and the seat of the pilot valve is moved in the same direction by the expansion of the sylphon N. Consequently, when the seat of the pilot valve moves through the same angle as the valve, there will be no further increase in pressure in line P. For a definite movement of the pen arm, there will be a definite expansion of the sylphon N to permit a definite pressure in line P, and to produce definite compression in spring O. Therefore, a definite pressure in the outlet



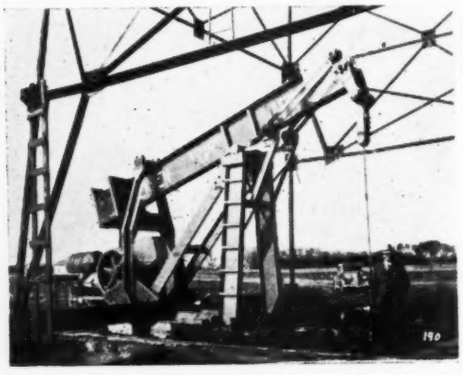
LINK-BELT *Vibrating* SCREEN

for Reconditioning Rotary Mud

● The Link-Belt screen has proved by actual performance that it is the lowest cost method of reconditioning rotary mud. It has many exclusive advantages such as—larger screening area—longer life of screen cloth—ease of transportation—minimum head room required, etc. Send for folder No. 1772. 7323

LINK-BELT COMPANY

Philadelphia Los Angeles New York Dallas Houston Tulsa



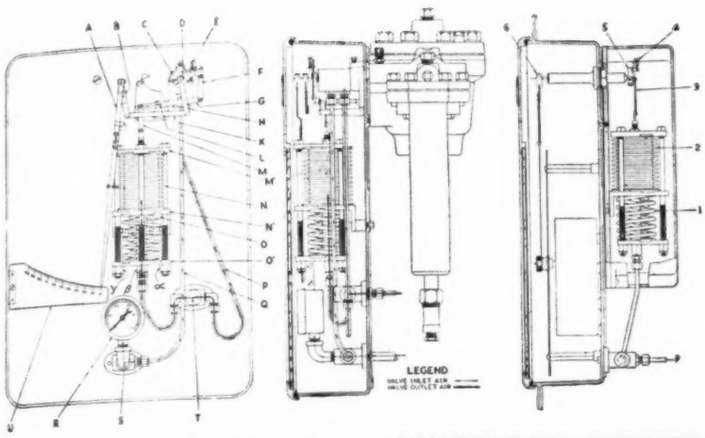
REWARD! (To Producers)

We reward every producer who shows any interest: We send him information about an easy-running, trouble-free pumping unit that cuts costs to where proration doesn't hurt so bad.

Of course you, like most producers, are satisfied with the equipment you now use. But if there is something better, you want to know about it. We've made pumping equipment for 19 years. We build everything we've learned into JENSEN Straight-Lift JACKS. Do you want to know about 'em?

Ask your JENSEN Dealer or wire us at Coffeyville.

JENSEN BROTHERS MANUFACTURING CO. . . . *Coffeyville, Kansas*



line P will be obtained for each position of differential arm A.

Outlet line P is connected to the receiving instrument, which consists of a spring-loaded sylphon 1-2 (exactly similar to sylphon N-O). Sylphon 1-2 —through link 3, adjustment 4, and lever 5—actuates pen arm 6. As there is a definite position of sylphon 1-2 for each pressure in line P, just as there is for sylphon N-O, pen arm 6 will assume a definite position on the chart for each definite position of pen arm A in the sending instrument, and the positions of these two pen arms always will be the same.

Diesel Battery Line by Goodrich

A COMPLETE line of specially-constructed batteries for Diesel starting service is announced by The B. F. Goodrich Company, Akron, Ohio. In the line are four 6-volt types, two 8-volt types, and ten 12-volt types.

Eight of the batteries are of conventional construction and eight are built with the Kathanode construction. Port Orford Cedar separators, the highest grade wood known for this purpose, are used in the separators of the conventional type.

In the Kathanode type flexible spun glass Kathanode retainer mats are used on both sides of the positive plates, holding the active materials adjacent to them for a longer period, and thus increasing battery life.

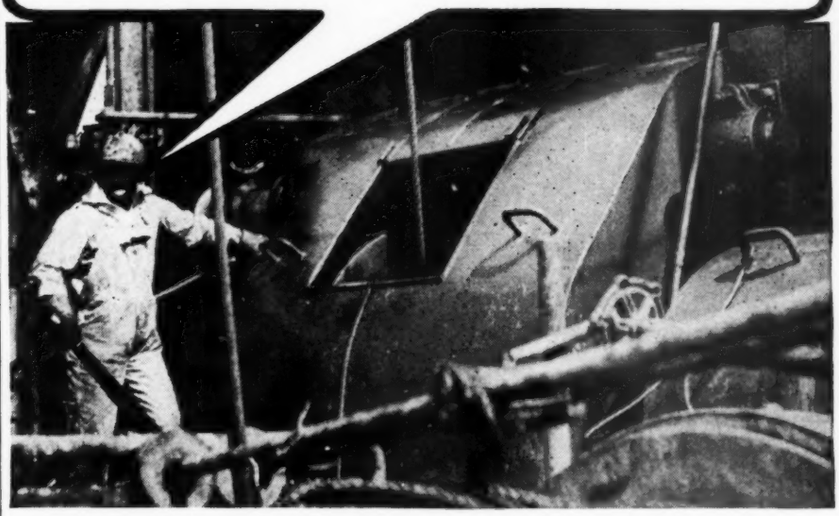
The new line of Diesel batteries, according to the manufacturer, are built with thinner plates than heavy-duty types, giving instant reaction and quick motor turnover. Adequate power is available instantaneously to ignite the fuel oil and start the motor in coldest weather, it is stated.

All batteries, except the 8-volt types, are assembled in hard-rubber cases. The 8-volt types are assembled in hard-rubber jars and wood cases. connectors are of solid lead, except those on the 8-volt types, which are of flexible copper with lead coating to prevent corrosion.

Cell covers are made of reinforced hard rubber, terminal posts are of the braced type, with rubber gasket seals and locknuts to prevent acid seepage, allowing for vibration of plates without causing damage. Splash-proof vents are used and ample sediment space provided to prevent battery failure as a result of short circuits caused by an accumulation of sediment touching the plates.

The B. F. Goodrich Company also has a complete line of batteries for automobiles, trucks, buses, tractors, and other vehicles.

HERE'S A LINING THAT CAN STAND THE GAFF!



TOM SINGLER operating one of the largest and best drilling rigs in the Corpus Christi oil fields, owned by W. A. Richardson Petroleum & Drilling Corp., and equipped with J-M Giant Rotary Lining, Style 410. Both owner and driller are sold on the superior, longer service of this rugged brake lining.

Here's why J-M Lining, Style 410 is the choice on so many Drilling Rigs:

AN EVEN FEED-OFF
. . . assuring better controlled drilling.

LESS SMOKING AND DUSTING
. . . working conditions greatly improved.

SCORING TENDENCY REDUCED
. . . life of brake rim is lengthened.

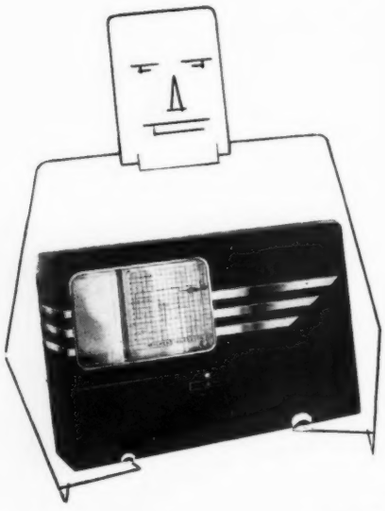
QUIETER BRAKES
. . . less nerve strain on drilling crews.

Johns-Manville GIANT ROTARY LINING Style 410

JM

WRITE NOW—for full details on our complete line of friction materials. Address Johns-Manville, 22 East 40th Street, New York City.

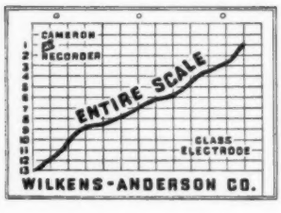
Robot pH Testing



INSURES FREEDOM FROM CORROSION IN THE STILL

The Cameron pH Recorder uses the glass electrode . . . the only one guaranteed for trouble-free operation on gaseous water encountered in the still.

FLAT CHART EASY TO READ, FILE AND COMPARE



The permanent record may be written for THREE tanks, with ONE Recorder sheet . . . on the Cameron

★ Ask for Bulletin PE5, giving details of your requirements.

LABORATORY SUPPLIES AND CHEMICALS
WILKENS-ANDERSON CO
111 N. CANAL ST. CHICAGO ILL.

Baker Wash-Down Whirler Equipment

THE Wash-Down Whirler equipment, including the Baker Cement Wash-Down Whirler Float Shoe and the Baker Cement Wash-Down Whirler Guide Shoe, are newly-developed and improved products of Baker Oil Tools, Inc., Huntington Park, California.

The accompanying illustration of the Wash-Down Whirler Float Shoe shows the side ports that lead out of the valve chamber, and are baffled to direct any fluid downwardly. When circulating, while running in the hole, the whirling, hydraulic action imparted to the fluid effectively washes away the bridges that may be encountered, and the formation thus removed is circulated up the hole as the work proceeds.

The whirling action is also effective in washing the side walls of the hole, but any tendency toward breaking down the side walls of the hole is prevented by the downward, rather than outward turbulence as the fluid leaves the shoe.

Baker Cement Wash-Down Whirler Float Shoe

When cementing operations are begun, the down-whirler principle insures a free movement of the cement slurry and greatly increases chances for complete encasement of the pipe with a uniform body of cement, with possibility of channelling reduced to a minimum, the manufacturers state.

Coffing "Safety Pull"

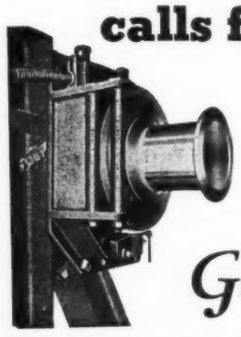
WHAT is said by the manufacturers to be the most "foolproof" hoist ever offered industry has been developed by Coffing Hoist Company, Danville, Illinois. It is called the Coffing "Safety Pull."

Newest of the many safety features is the push button control. When the load has been elevated and it is desired to lower the hoist, the operator simply pushes the button and the hoist's action is reversed. This control also acts as a safety stop; if the worker's hand should slip off the handle while operating, this device automatically and positively locks the handle before it can revolve or cause any damage.

Two other separate safety stops pre-

MODERN DRILLING

calls for a



Geared

CATHEAD

The high speeds at which many line shafts are being run in today's drilling operations makes it practically imperative that a cathead be geared down to reduce the terrific impact when breaking tool joints. Conventional catheads, when slowed down, lose most of their power, but not the MacClatchie Gearomatic. Due to its patented gear arrangements, it rotates at HALF the line shaft speed yet gives DOUBLE the power.

It breaks the tightest joints with ease and without damage to tongs, tong dies, or other equipment.

A positive kick-out and slow motion insures greater safety. The positive kick-out permits one revolution, and only one, per pull. Consequently, there is no danger of fouled lines injuring workmen or damaging rig equipment when you use the MacClatchie Gearomatic Cathead.

MacCLATCHIE MANUFACTURING CO.

COMPTON, CALIF. HOUSTON, TEXAS

Export:

Geo. R. Woods, 17 Battery Pl., New York

Forging Ahead
FOR YOUR CONTINUED COMFORT

Announcing

the addition of this fine 200 room modern hotel to our now famous "Host to the Nation" family.

Hotel LAMAR
MERIDIAN, MISS.
Rates from $2.50 • W. T. Mobley, *Manager*

Plus

JUNG HOTEL, New Orleans, La. Vast improvements now completed. The South's finest convention facilities — new Coffee Shop — Cocktail Lounges, all air-conditioned. Finer room appointments.

Plus

STEPHEN F. AUSTIN, Austin, Texas Now 350 rooms — 5 air-conditioned floors — 150 new guest rooms. New mode room furnishings for ease and comfort.

Equals

Affiliated
NATIONAL HOTELS

ALABAMA
HOTEL THOMAS JEFFERSON.. Birmingham
ILLINOIS
HOTEL FAUST .....Rockford
LOUISIANA
HOTEL JUNG.....New Orleans
HOTEL DESOTO .....New Orleans
MISSISSIPPI
HOTEL LAMAR.....Meridian
HOTEL RIVIERA.....Biloxi
NEW MEXICO
HOTEL CLOVIS.....Clovis
OKLAHOMA
HOTEL HUBER.....Muskogee
HOTEL OKLAHOMA BILTMORE..Oklahoma City
HOTEL BELMONT.....Okmulgee
HOTEL SAPULPA.....Sapulpa
HOTEL ALDRIDGE.....Wewoka
TEXAS
HOTEL STEPHEN F. AUSTIN.....Austin
HOTEL SETTLES.....Big Spring
HOTEL BROWNWOOD.....Brownwood
HOTEL SOUTHERN.....Brownwood
HOTEL LAGUNA.....Cisco
HOTEL CLIFF TOWERS.....Dallas
HOTEL DONNA.....Donna
HOTEL CORTEZ.....El Paso
HOTEL TEXAS.....Fort Worth
HOTEL BUCCANEER.....Galveston
HOTEL JEAN LAFITTE.....Galveston
CORONADO COURTS.....Galveston
MIRAMAR COURT.....Galveston
HOTEL CAVALIER.....Galveston
HOTEL LUBBOCK.....Lubbock
HOTEL FALLS.....Marlin
HOTEL GHOLSON.....Ranger
HOTEL CACTUS.....San Angelo
ANGELES COURT.....San Antonio
VIRGINIA
HOTEL MOUNTAIN LAKE.....Mountain Lake

AFFILIATED
NATIONAL HOTELS
HOST TO THE NATION
C-8-222

vent the handle from whirling and causing injuries to workmen.

A new intermediate locking pawl works alternately and intermediately with the main locking pawl and enables the load to be stopped in locking position at half the length of the regular stroke. This added pawl also serves as an extra safety.

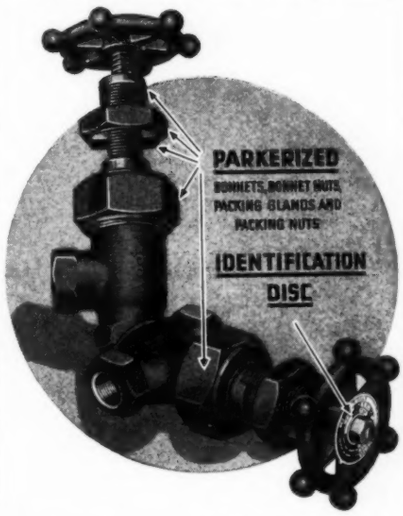
In the case of excessive overloads, hazards are definitely avoided, as the "safety valve" handle bends before any other part of the hoist will give. This serves as a warning to prevent chain from breaking or hooks from straightening out and dropping loads.

Utmost safety, even for inexperienced workmen, and ease of operation are emphasized in every detail of this hoist. Full safety, too, is assured the load and all that is beneath any suspended load, the makers state.

Coffing "Safety Pulls" are made for loads from ¾ to 15 tons, weighing from 14 to 150 pounds. Each hoist is factory tested to lift 100 percent overload.

Vogt Drop-Forged Steel Valves

VOGT drop-forged steel valves, made by the Henry Vogt Machine Company, Louisville, Kentucky, are now available with Parkerized valve bonnets, bonnet nuts, packing glands, and packing nuts. This rust-proofing



process eliminates galling of threads due to atmospheric corrosion, thereby making it easy to service the valve and maintain high operating efficiency, it is stated.

Another feature is the identification disc held in place by the handwheel nut. This disc records the valve size, catalog number, working pressure and temperature, and style of trim, thus making it easy to order proper replacement parts if that should become necessary.

DO THE JOB.

IN half THE TIME!

MIDCO
PLUNGER TYPE CLEAN-OUT
BAILER

★ Helps Eliminate Fishing Jobs. Interchangeable Heads and Bottoms Assure Extreme Adaptability.

★ Operates Safely — Efficiently.

★ Seamless Steel Tube Provides Maximum Strength and Ruggedness.

★ One Piece, Large Opening, Patented Bottom—Exclusive Feature.

MIDCO BAILERS are being accepted with great enthusiasm by operators in all oil producing states. The Midco Bailer will pay you a profit over what you are trying to save with obsolete or inefficient equipment you might be using. Write or call for names of distributors in your territory.

FOR RENTAL OR SALE
See Comp. Cat. Pgs. 1421-22

MIDCO
BAILER CO.
(Formerly Ideal Bailer Co.)
OKLAHOMA CITY, OKLA.

Pat. Nos. 2061489, 2090055, 2090209.
Other Patents Pending
IF IT'S MIDCO IT'S MODERN

Pittsburgh Equitable Distributor for Stupakoff Lines

It has been announced that the Pittsburgh Equitable Meter Company of Pittsburgh, Pennsylvania, has been appointed sole distributor for the Stupakoff bottom-hole pressure gauge and bottom-hole sampler.

The Stupakoff Laboratories of Pittsburgh have been manufacturing and marketing these devices for several years, during which period they are said to have met with considerable favor by production engineers and geologists throughout the industry.

In commenting upon this latest addition to the Emco line, Colonel W. F. Rockwell, president of Pittsburgh Equitable Meter Company, said:

"A study of these devices by our company has indicated that their design is fundamentally sound and that they provide a degree of accuracy in making bottom-hole determinations not previously available. Stupakoff Laboratories are ideally equipped to handle the precision workmanship required in their manufacture. We, in turn, through our wide acquaintance with the oil industry, believe that we can better serve potential users by acting in the capacity of sole distributor for this equipment."

Oil men attending the International Petroleum Exposition in Tulsa are invited to inspect these products in a special exhibit at the Hall of Science where cut-away samples will be on display.

D. C. Norcross of Petreco Passes Away

D. C. Norcross, well-known throughout the petroleum industry because of his many years as president and general manager of the Petroleum

Rectifying Company of California, passed away at his home in Bel Air, California, on March 23, following a prolonged illness. Funeral services were held at the Little Church of the Flowers, Forest Lawn Memorial Park in Glendale, on March 25.

Norcross, a native of California, was one of the original group of organizers of the Petroleum Rectifying Company of California at its inception in 1911, serving as president until the latter part of 1937 when he retired from active service and became honorary president. He took an active part in all activities pertaining to the petroleum industry, and traveled extensively throughout this and foreign countries in connection with this work. At the time of his death he was the oldest member of the company in point of service, having devoted 26 years of his life to continuous activity as an executive officer.

Lufkin Opens Shreveport Office

The Lufkin Foundry and Machine Company, Lufkin, Texas, manufacturers of Lufkin pumping units, has opened an office in Shreveport, Louisiana, to serve the oil fields of North Louisiana and Arkansas. The office is in charge of C. S. Hardin and is at 312 Ward Building.

NOW
Completely
Air Conditioned
Enjoy Refreshing
Restful Sleep
Every night this summer
In Cool, Inviting Guest Rooms
at the TEXAS STATE
From "Stem to Stern"—All
Rooms are Weather Controlled
You'll wake up smiling after a cool restful night's sleep at the Texas State. Every guest room, every nook and corner in this new modern hotel is scientifically air conditioned and designed for your comfort. All rooms have both tub and shower bath and circulating ice water. The famous new State Grill and Mezzanine Dining Room offer you a choice of two exceptionally delightful places to dine.
In HOUSTON
TEXAS STATE
Hotel
B. F. ORR
GEN. MGR.

"Pete" Small on Extensive South American Trip

O. D. "Pete" Small, special representative for Portable Rig Company, of Houston, Texas, is completing the sixth month of an eight-month tour of South American and Caribbean fields, having recently left Santiago, Chile, for Buenos Aires, which point he will use as a working base for the next two months.

O. D. SMALL

Small, who has represented Portable Rig Company in United States fields for more than a year prior to this tour, is well acquainted with South American conditions, having previously worked for major oil companies at various points there, and in the British West Indies and Mexican fields. He flew from Houston to Miami, Florida, early in December, 1937, and spent a month in and around Port of Spain, Trinidad, British West Indies. He proceeded from there to Caripito, in Eastern Venezuela, and thence to Maracaibo. After working this and nearby points for more than a month, he traveled down the Magdalena River into Colombia, calling at Bogota and Barranquilla. The next leg of the journey took him to Cristobal, Panama, from which point he flew to Guayaquil, Ecuador, thence to Talara and Lima, Peru, and on to Santiago, Chile.

From Buenos Aires, Small will cover the Argentina fields, and will spend some time in Patagonia, the remote southern point of activity on the continent. En route home from Buenos Aires he will cover Uruguay and Paraguay, will make a stop-over at Rio de Janiero, and again will stop off at Port of Spain, Trinidad.

Continental Supply Opens Two New Stores

The Continental Supply Company has announced the opening of two additional stores. A branch at Noble, Illinois, under the direction of L. C. Combs, was opened May 1st. At Cotton Valley, Louisiana, a new store was opened on May 10th under the direction of Dean P. Davis, former manager at Talco, Texas, who has been succeeded there by C. A. Brownfield.

C. J. Coberly in Mid-Continent

C. J. Coberly, president of Kobe, Incorporated, Huntington Park, California, has, the last few weeks, been

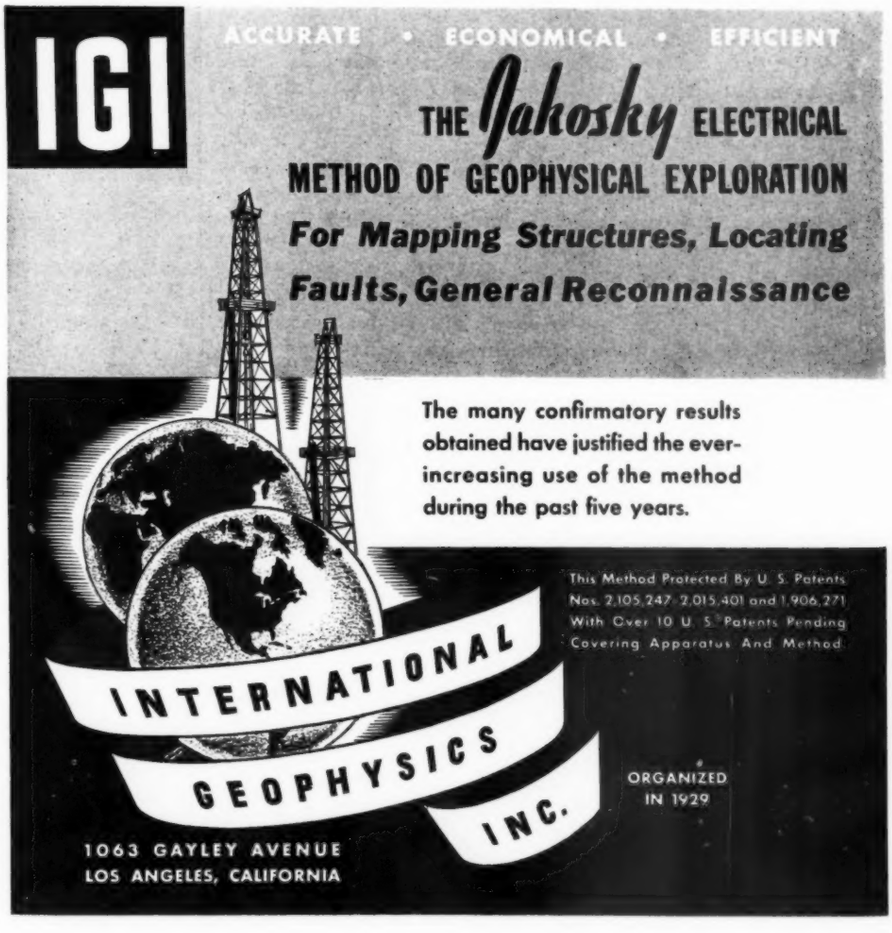
C. J. COBERLY

on one of his numerous business visits to the company's branch in Oklahoma City. While there he personally inspected the Kobe hydraulic pumping plants operating in the Oklahoma City oil fields, a large number of which have been installed during the last year. Coberly is now in attendance at the International Petroleum Exposition at Tulsa, and will attend the eighth mid-year meeting of the American Petroleum Institute at Wichita, Kansas, before returning home.

Death of Charles H. Shaw

Charles H. Shaw, for the last three years Philadelphia office manager for the Worthington Pump and Machinery Corporation, died at his home on April 15, 1938. Associated with Worthington since 1920, Shaw was manager of the corporation's Pittsburgh Office from 1928 to 1935.

Born in Owensboro, Kentucky, in 1898, he graduated from Syracuse University in 1919. Since that time, as a member of the Worthington organization, he served the corporation on several important assignments. Popular with his associates, and admired for his ability, his passing is a great loss to all who knew him.


IGI
ACCURATE • ECONOMICAL • EFFICIENT
THE Jakosky ELECTRICAL METHOD OF GEOPHYSICAL EXPLORATION
For Mapping Structures, Locating Faults, General Reconnaissance
The many confirmatory results obtained have justified the ever-increasing use of the method during the past five years.
This Method Protected By U. S. Patents Nos. 2,105,247-2,015,401 and 1,906,271 With Over 10 U. S. Patents Pending Covering Apparatus And Method
INTERNATIONAL GEOPHYSICS INC.
ORGANIZED IN 1929
1063 GAYLEY AVENUE
LOS ANGELES, CALIFORNIA

● **So surprising were the strengths revealed in careful tests of Williams' "Superior" Wrenches, that our engineers at first questioned their own findings. Such performance, as indicated by these tests, had never been associated previously with Carbon Steel wrenches. But developments in metallurgy, coupled with advances in manufacturing methods, have enabled Williams' engineers to produce an Improved Carbon Steel Wrench approximately *twice as strong* as old-fashioned wrenches of this type.**

Drop-forged from improved quality carbon steel and specially processed to Williams' exacting specifications, "Superior" Wrenches average *93% as strong as Alloy Steel Wrenches of similar size.* They are actually stronger than the Double Head Engineers' Pattern alloy wrenches which are of popular thin design. They cost considerably less! They provide a better hand grip than the usual thin alloy wrench . . . they insure greater and safer bearing on the nut. Make your next wrenches Williams' "Superiors" . . . . 50 patterns, over 1000 sizes.

J. H. WILLIAMS & CO.

261 Spring Street, New York

Headquarters for: Drop-Forged Wrenches (Carbon and Alloy), Detachable Socket Wrenches, Reversible Ratchet Wrenches, "C" Clamps, Lathe Dogs, Tool Holders, Eye Bolts, Hoist Hooks, Thumb Nuts and Screws, Chain Pipe Tongs, Vises, etc.

1-479

Get this FREE BOOKLET

Every mechanic and tool buyer needs this helpful, informative booklet. Complete tables give correct wrench opening for U. S., S. A. E., American Standard Nut and Cap Screw sizes. Data on wrench types and applications, how to select the proper wrench for your needs. Write your name and address in margin, tear off on dotted line and mail.

M. D. Carrel Made Regional Sales Manager for Union Wire Rope

The Union Wire Rope Corporation, of Kansas City, Missouri, and Tulsa, Oklahoma, has announced the appointment of M. D. Carrel as manager of sales for its central territory, with headquarters at Chicago.

M. D. CARREL

Carrel has had a notable career in government and sales positions. Among his government positions, beginning in 1899, were those of: secretary to General Wood, military governor of Cuba; secretary Dominican Customs Receivership established by President Theodore Roosevelt; deputy surveyor, Manila, P. I., engaged in special study of Philippine trade requirements; secretary of Puerto Rico by presidential appointment, and on several occasions acting governor; assistant vice-president, American International Corporation, reporting on business in Latin America; drafting officer, State Department, Washington, D. C., engaged on matters related to U. S. trade with foreign countries; vice-president Ulen and Company and Ulen Engineering Corporation, in charge of development of business in Latin America; director and economic advisor, Foreign Bond Associates, Inc.; regional manager, Housing Division, P.W.A.

While connected with Ulen and Company he personally conducted negotiations and signed contracts for $40,000,000 of design, financing, and construction of public works in Latin America, including the Bolivian Railway.

Carrel's business address is Union Wire Rope Corporation, 431 Pershing Road, Chicago, Illinois.

Emsco Derrick Makes Two Promotions

G. W. WALTON

S. W. WEBSTER

Announcement was made recently by the Emsco Derrick and Equipment Company of the appointment of G. W. Walton to the position of vice-president in charge of the Mid-Continent machinery division, and S. W. Webster to the position of manager of Mid-Continent machinery division sales and service. Both men are well known throughout the oil country, having had long experience in the development of sales of oilfield equipment, and having been associated with Emsco for many years.

Walton will be stationed in Dallas, and Webster will retain his present location in Houston where Emsco is rapidly expanding its present manufacturing facilities.

Lincoln Electric Manufacturing Subsidiary in Australia

J. F. Lincoln, president, The Lincoln Electric Company, Cleveland, Ohio, manufacturers of arc-welding equipment, announces establishment of a manufacturing subsidiary to be called Lincoln Electric Company (Australia) Pty., Ltd., at Sydney, Australia. A suitable factory has been purchased and arc-welding equipment manufacturing operations will begin in a year's time.

Lincoln believes the establishment of the Australian plant will increase the scope of welding throughout the commonwealth, because of the increased speeds and lower costs made possible by the equipment to be built. He expresses great faith in Australia's industrial future.

When in Australia Lincoln visited all the capital cities, giving a series of addresses before various engineering societies and groups on developments in the art of welding. Great interest in welding was indicated by the large, enthusiastic attendance wherever he spoke. He is expected back in the United States this month, returning by way of South Africa and England in both of which countries the Lincoln company has holdings.

Vapor Recovery Systems Company Expanding

Vapor Recovery Systems Company, Compton, California, has in progress an expansion program that includes the addition of 15,000 sq. ft. of shop floor space and the tripling of present office space and facilities. The capital outlay for new buildings and machinery will total $25,000 to $35,000.

According to Frank V. Long, president, 168 complete vapor-recovery systems have been installed in the Long Beach area in recent months. Orders are being booked from Canada, Roumania, and Poland, and with the approach of winter in the Southern Hemisphere, complete systems are being installed in Peru, Bolivia, and other South American countries, he says.

Many units of standard type machine tools, including lathes, boring and milling machines, and drill presses, have been ordered, and some have arrived before the completion of the new building.

W. B. Whenthoff Joins Staff of Tube-Turns

W. B. Whenthoff, formerly with the Big Three Welding and Equipment Company of Tulsa, and well-known to oil men throughout the Mid-Continent area, has recently joined the sales organization of Tube-Turns, Inc., as district manager for the Mid-Continent.

Whenthoff has had wide experience in welding operations of all kinds and is well qualified to discuss welding problems in connection with piping construction and design.

W. B. WHENTHOFF

Now! **A NEW STEM...**

TO FURTHER INCREASE THE EFFICIENCY OF

"BOSS TRI-DUPLEX" Rotary Hose Couplings

The Most Powerful Ever Built!

Recently perfected, then thoroughly field-tested and now ready for distribution . . . a new, greatly improved stem for "BOSS TRI-DUPLEX" Rotary Hose Coupling Style Z! Made of finest quality cold drawn seamless alloy steel tubing, heat treated . . . providing greater resistance to wear and abrasion and completely eliminating porosity. Smooth bore permits frictionless flow. Machined corrugated exterior protects tube and provides excellent sealing surface. Head section is *welded* on, at both thread and shank ends. Collar for clamps has three-bridge, built-up reinforcement. Large wrench section, round instead of hex, permits use of chain tongs.

Despite these important advantages and the *real* savings they provide through longer wear and fewer replacements, this new stem carries no advance in list . . . *it sells for the same price as the present stem* for this Coupling.

"BOSS TRI-DUPLEX" Rotary Hose Couplings

are without equal in ability to meet every requirement for oil well drilling. Guaranteed to be leak-proof, seepage-proof, and blow-off proof. Giant Style Z, the heavier, more powerful type, will withstand highest pressures and the most severe stresses, strains and vibrations encountered in this service. The 2½" Coupling has been tested under hydrostatic pressure to 11,000 lbs. per square inch; the 3" size to 10,200 lbs.

* * *

Your Jobber or Supply House can furnish "BOSS" Couplings and other dependable DIXON products promptly. Ask for Catalog or write direct for complete information.

DIXON

VALVE & COUPLING CO.

MAIN OFFICE AND FACTORY

LOS ANGELES **PHILADELPHIA** HOUSTON

STOP *the bother of changing* Chaser Dies

RIDGID

No. 65R Threads 1" to 2" Pipe with ONE Set of Chasers

Instead of 16 chaser dies to lug around, to risk losing, to waste valuable time changing every time you want to thread different size pipe, this threader has only 4 — and they stay in the threader.

A quick shift of the setting post and you're ready to cut perfect threads on 1", 1¼", 1½" or 2" pipe, any metal — over or under size, drip threads or short nipples — a convenience that runs into real money saving.

Like many thousands of users, you go for the new style work-holder that clicks to pipe size with a twist of the gauge ring and tightens with one screw. No bushings to bother with.

Plenty of other efficiency features in this rugged modern threader. The more experienced a judge of pipe tools you are, the more satisfaction you get out of owning and using this RIDGID No. 65R. Try one at your Supply House — buy it for better, faster, easier threading.

RIDGID No. 65R has feet which make it stand up conveniently on the floor.
No. 65R, 2-handle ratchet die.
No. 65, 2-handle plain die.

THE RIDGE TOOL CO., ELYRIA, O.

RIDGID Practically Stops Pipe Wrench Repair Expense

Save 75% of what it's been costing you for wrenches on the sick list and repairs — by buying RIDGIDs. Ask your Supply House.

RIDGID PIPE TOOLS

Visit our Booths, Nos. 28, 29, 30 in the Texas Bldg., at the Oil Show, Tulsa, Oklahoma, May 14-21

Atlas Supply Opens Stillwater, Oklahoma, Store

F. E. MAXWELL

J. H. MUIR

Anticipating extensive development of the immediate area, and for the purpose of serving numerous fields in surrounding territory, Atlas Supply Company has opened a store at Stillwater, Oklahoma. F. E. Maxwell, stationed at Oklahoma City, will be district manager in charge of the Stillwater store. J. H. Muir, at the Blackwell store for several years, will be manager at Stillwater.

Chemical Process Company in Larger Quarters

The Chemical Process Company, oil-well acidizers, and Pitzer and West, independent oil operators, Breckenridge, Texas, have moved their offices to larger quarters. The two companies now occupy the entire ninth floor of the Burch Hotel Building.

Officers of the Chemical Process Company are C. K. West, president; P. W. Pitzer, G. R. Whitney, and M. E. Chapman, vice-presidents; and A. J. Buchanan, secretary-treasurer.

Wall Chart on World's Deepest Wells

Patterson-Ballagh Corporation has just published a wall chart bringing up to date all data on the wells drilling deeper than 10,000 feet. This chart not only shows the Continental well and details of its production, casing, etc., but all wells in the various states. Free copies of this chart will be mailed to those requesting them from the Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

Executives Assigned New Duties

Three vice-presidents and two division managers of the Westinghouse Electric and Manufacturing Company have been assigned new duties in a revised schedule of responsibilities announced by President George H. Bucher.

Vice-President Ralph Kelly is placed in charge of sales of the company with headquarters in the Pittsburgh executive offices. Formerly he was in charge of Pittsburgh district works, including the headquarters plant at East Pittsburgh.

Vice-President R. B. Mildon assumes management of the East Pittsburgh division, coming from Philadelphia where he had charge of the Steam and Stoker departments.

Vice-President N. G. Symonds, long associated with sales operations, will devote his time in the sales department to specific customer activities, association work, and special duties as assigned.

Other appointments list Roy A. McCarty, formerly manager of the Small Motor Division at Lima, Ohio, as transferred to South Philadelphia as manager of the Steam and Stoker Division; and B. H. Lytle, formerly a division manager in East Pittsburgh, goes to Lima as manager.

N. G. A. A. Holds Instructive Meeting

The automotive industry again took a leading part in the annual convention of the Natural Gasoline Association of America, when representatives of that industry presented their discussions in the meetings, May 11th to 13th, at the Hotel Tulsa, Tulsa, Oklahoma.

A joint paper on "Road Test Methods and Results from the Standpoint of the Automotive Industry" by Wheeler G. Lovell, J. M. Campbell, and M. J. Mulligan, Research Laboratory Division, General Motors Corporation, Detroit, was a feature of the technical session of Thursday, May 12th. This paper was a discussion of the paper by T. W. Legatski, Phillips Petroleum Company, Bartlesville, Oklahoma, on "The Fuel System Characteristics of Vapor Locking Automobiles as Determined by the Pawhuska Road Tests of 1937." Legatski served as chairman of the steering committee for these tests, which were a joint project of the Natural Gasoline Association of America and the Western Petroleum Refiners Association, and his paper is the final report of that committee. Other automotive men invited to present discussions were E. H. Shepard, Chevrolet Motor Company, Detroit; Frank Mock, Bendix Corporation, and W. S. James, The Studebaker Corporation, both of South Bend, Indiana.

Another technical session was devoted to the discussion of economics within the industry and the subject was approached from two angles. Arch L. Foster, *National Petroleum News*, Cleveland, Ohio, discussed the "Trends in Refining Processes and their Effect on Natural Gasoline Operations," and R. C. Alden, research director, Phillips Petroleum Company, Bartlesville, presented a paper on natural gasoline marketing with particular reference to sale on the inherent value of natural gasoline rather than selling just to get the material into the market. Both of these papers were discussed from the floor, the former by C. R. Williams, Continental Oil Company, Ponca City, and the latter by Mark Patten, Hurley Gasoline Sales Company, Tulsa, Oklahoma.

The Convention was officially opened Wednesday afternoon, May 11th, with an address by J. W. Newton, vice-president in charge of refineries, Magnolia Petroleum Company, Dallas. Newton has a wide knowledge of natural gasoline operations and their relation to the refining industry. J. A. LaFortune, vice-president, Warren Petroleum Corporation, Tulsa, delivered his annual address at this same session and it was followed by the annual reports of the various committees. In view of the large amount of work done by these groups, their reports were of unusual interest to the industry.

Friday morning, May 13th, was given over entirely to discussion of field operating problems when field and laboratory men competed for cash prizes in the presentation of the most valuable original ideas for the simplification of their own particular work. F. E. Fisher, Skelly Oil Company, Burbank, Oklahoma, had charge of this meeting and was assisted by a committee of judges who selected the most valuable contributions.

Immediately following this session registrants at the convention were special guests of the management of the International Petroleum Exposition where they were given a prevue of the exhibits Friday afternoon. A barbecue dinner was served in the new cafeteria building that evening when natural gasoline men were the guests of Warren Petroleum Corporation.

C. W. Sulzer Transferred

Charles W. Sulzer, service engineer, Baroid Sales Department, National Pigments and Chemical Division of National Lead Company, has been transferred from Odessa, Texas, to Hobbs, New Mexico.

Type EA
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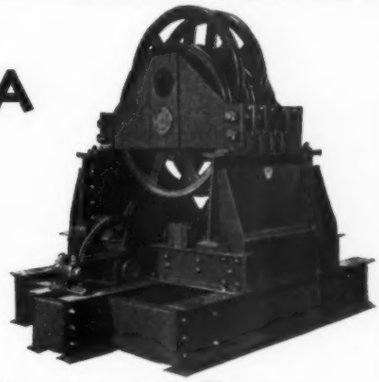
Crown
Block



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C. N. G. A. Holds Last Meeting of Fiscal Year

The California Natural Gasoline Association held its final program of the fiscal year at Barker Brothers' Mary Louise Tea Room, Los Angeles, on May 5, and as a grand windup to a highly successful term, a program of a somewhat unique type was presented. The speaker of the evening, Robert B. Bowman, Research and Development Department, Standard Oil Company of California, presented a paper entitled, "Equilibrium Relations for Paraffin Hydrocarbons at High Pressures and Ordinary Temperatures." This presentation brought to the members of the association recently-developed pertinent data on hydrocarbon equilibria that are of vital significance in almost every phase of the natural gas and gasoline business, and are of equal importance in field and refinery engineering.

Bowman is recognized as an authority on the subject, and his address afforded one of the liveliest sessions of the year, particularly as prepared discussions were interjected by Dr. W. N. Lacey, California Institute of Technology, and E. G. Ragatz, Union Oil Company.

TRADE LITERATURE

FOUR NEW BULLETINS have been issued by the Lane-Wells Company, Los Angeles, California, describing their services. The bulletins discuss the Lane-Wells Photo-Record Go-Devil (inclinometer instrument); the Lane-Wells Knuckle Joint for directional drilling; Lane-Wells Small Photo-Record Magnetic Single-Shot Survey Instruments; and the Standard Photo-Record Magnetic Single-Shot Survey Instruments.

●

OIL WELL SUPPLY COMPANY, Dallas, Texas, has issued three new bulletins, available upon request, as follows:

Bulletin No. 184—"Oilwell" No. 6-P Power Driven Pump.

Bulletin No. 147—"Oilwell" Cable-Tool Drilling Units.

Bulletin No. 173—"Oilwell" Packers.

●

PAMPHLET No. A-276-BB entitled "International Oil Field Power" has just been released by the International Harvester Company, Chicago, Illinois. The bulletin contains descriptions and illustrations of 11 power units for operation on natural gas, gasoline, distillate, or Diesel fuels, and ten tractors used in oil-field work.

●

THE ASSOCIATION OF CONSULTING CHEMISTS AND CHEMICAL ENGINEERS, INC., 50 East 41st Street, New York City, has issued its 1938 directory of members. In addition to the customary data found in such directories this publication contains details concerning the work the members are especially prepared to undertake as consultants. A copy will be sent free upon request.

●

A FOLDER published by the General Electric Company, Schenectady, New York, contains information concerning the company's vertical, hollow-shaft, induction motors that are specifically designed to meet operating requirements of modern deep-well turbine pumps.

●

A NEW FOLDER describing the various styles and sizes of Rex oil-field chains, designed primarily for use on rotary drilling rigs, has been issued by the Chain Belt Company, Milwaukee, Wisconsin.

Southwestern Gas Measurement Short Course Highly Successful

The 14th annual Gas Measurement Short Course, held at the University of Oklahoma at Norman, Oklahoma, April 19, 20, and 21, 1938, was proclaimed by all attending as being the most successful yet conducted.

The principal address of the meeting was made by R. W. Hendee of the Colorado Interstate Gas Company, Colorado Springs, Colorado. Hendee's address was followed by the report of the committee on "Study of Practical Methods," which was made by Earl Kightlinger of the Arkansas-Louisiana Gas Company, Shreveport, Louisiana.

Each afternoon during the school 18 classroom papers were presented by authors selected from the university faculty, the manufacturers' personnel, and men of the industry. All classes were well attended, and the interest in the subjects was manifested by the numerous discussions following the presentation of each paper.

Two interesting and constructive papers were presented before the general assembly on Wednesday morning. The first subject dealt with "Fundamental Principles of Orifice Meters," which was presented by A. D. McLean, Pittsburgh Equitable Meter Company, and the second paper, "Fundamental Principles of Displacement Meters," by A. F. Benson, American Meter Company.

On Thursday morning, J. H. Page of the Kansas Corporation Commission presented a paper before the general assembly on "The Major Gas Fields and Reserves of Kansas," and Dr. R. L. Huntington of the University of Oklahoma Faculty a paper on "Chemical Analysis of Gases."

L. G. Rheinberger, Sinclair-Prairie Oil Company, Tulsa, Oklahoma, the newly elected chairman of the general committee of the Southwestern Gas Measurement Short Course, was formally installed in office and presented with an inlaid walnut box containing a rosewood gavel by the retiring chairman, Gilbert Estill, Oklahoma Natural Gas Company, Tulsa, Oklahoma.

Baird Moves Into New Quarters

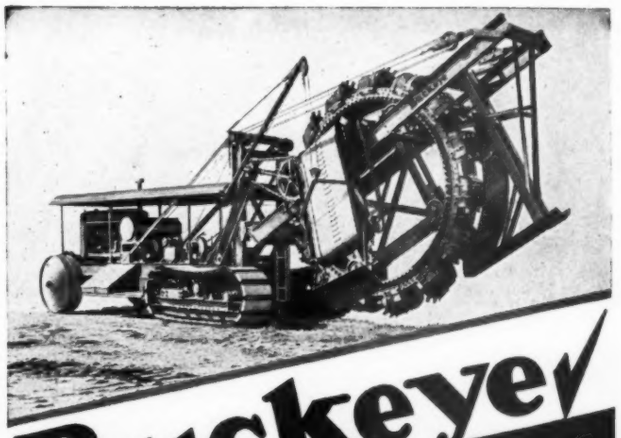
The Baird Manufacturing Company, Tulsa, Oklahoma, is now in its new and larger quarters at 3105 Sand Springs Road.

The company specializes in the manufacture of fluid-seal check valves for installation in underground oil-well pumps, presenting a grade and type to meet all fluid lift problems.

The products also include rig iron and pumping well and lease tool equipment for operating properties that feature increased safety factors to reduce maintenance hazards.

Direct sales representation is maintained in the oil fields of Arkansas, Kansas, Oklahoma, Louisiana, and Texas with deliveries through the recognized oil-well supply trade channels, and export sales through the New York office in the Graybar Building.

The officers include L. D. Baird, president, A. R. Simons, treasurer, and Joseph A. Gill, jr., secretary.



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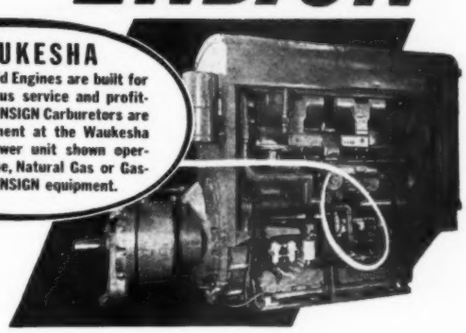

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Marley Company in Its New Building

The Marley Company, manufacturers of all types of water cooling equipment for industrial and air-conditioning application, recently moved into its big new building at 3001 Fairfax Road, in Kansas City, Kansas. The main structure, 180 ft. by 180 ft., houses the factory and warehouse on the first floor with national headquarters offices on the second. It is equipped with a modern heating and ventilating plant, including 32 tons of air conditioning for the offices. The Marley plot, in the well-known Fairfax Industrial District, is 213 ft. by 415 feet.

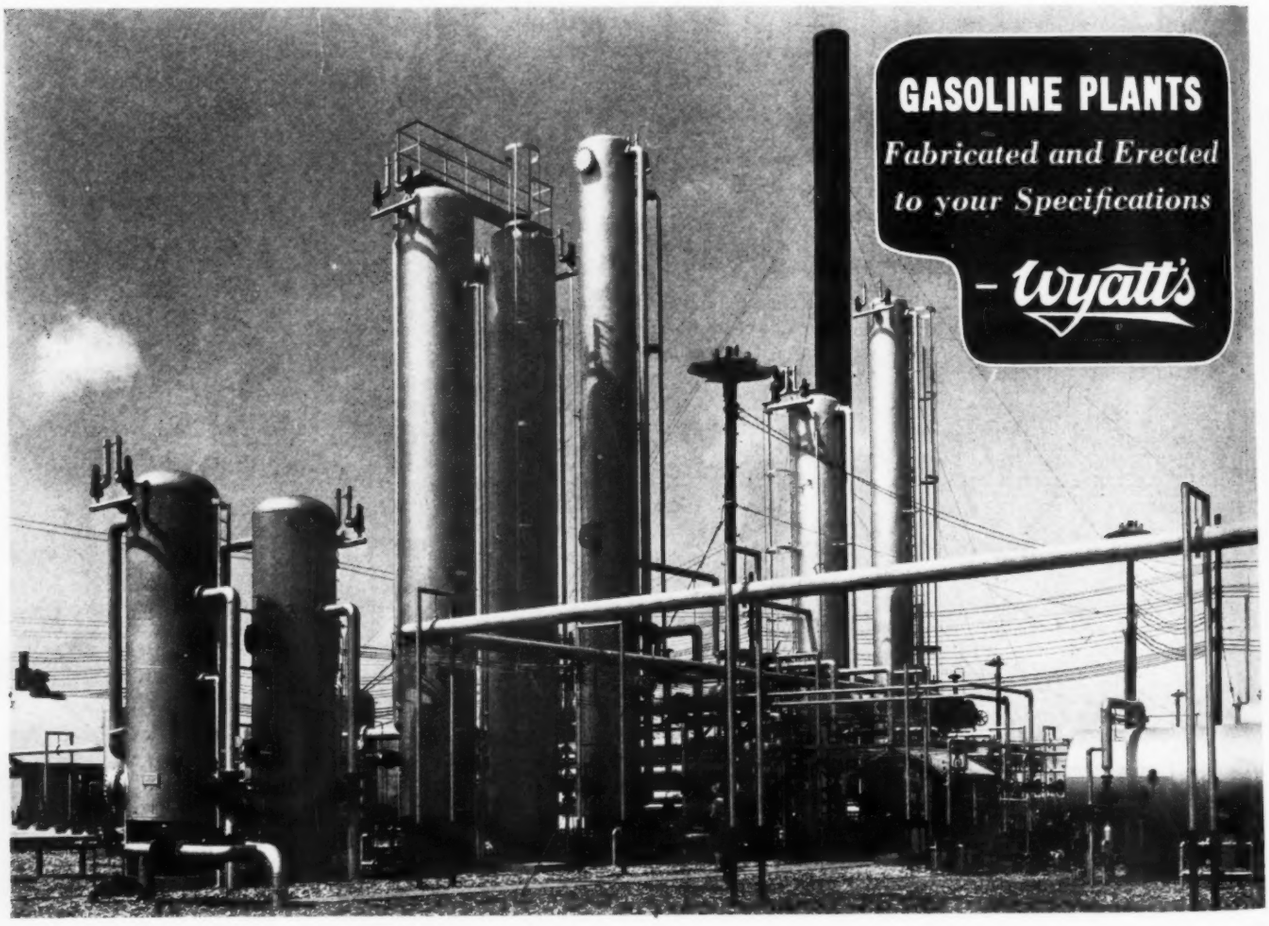
The Marley Company began in 1922 as manufacturer's representative for several nationally-known lines. In 1926 the Marley Spray Nozzle was perfected and offered to the public. It met with immediate acceptance.

The only equipment similar to its present broad line, aside from the nozzle itself, marketed by the company during its first two years was spray ponds. Then Marley pioneered the application of spray distribution to atmospheric deck-type water-cooling towers. Their early ventures were a marked success and resulted in launching the company into still another phase of cooling work. Next, the same principle was applied to forced-draft towers. The first Marley forced-draft tower, featuring spray distribution (rather than wood fill), was sold in 1930, four in 1931, and from that time on the company's development in this field has been outstanding.

In addition to general office and sales staff at the new location, the company operates its own sales offices in New York, Cincinnati, Tulsa, Atlanta, and Los Angeles, with exclusive representatives in other large cities throughout this country and in Canada and Cuba. Officers of the company include, L. T. Mart, president; W. R. Kell, vice-president and general sales manager; J. C. Albright, vice-president; and Miss E. M.Kelley, secretary and treasurer.

Republic Steel Appoints New Pipe Jobbers

Three new jobbers for Republic tubular products have been appointed by Republic Steel Corporation, Cleveland, Ohio, according to an announcement by N. J. Clarke, vice-president in charge of sales. They are: American Wholesale Hardware Company, Long Beach, California; The Anderson Supply Company, Norwich, Connecticut; and Valley Supply Company, Springfield, Massachusetts.



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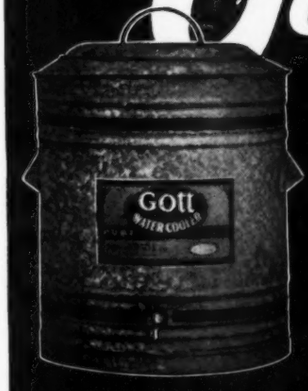

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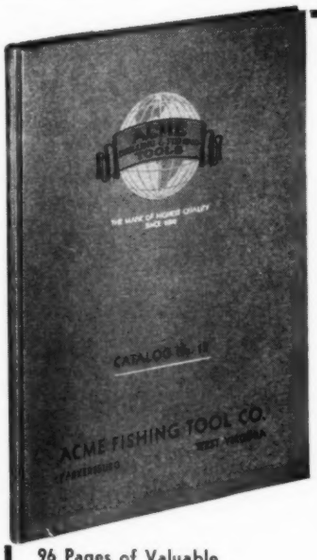

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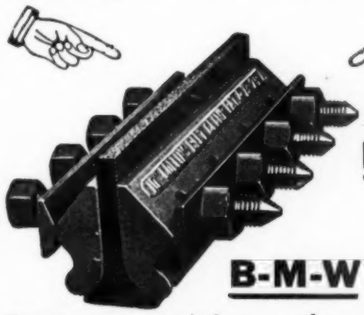

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THE *Petroleum* Engineer's

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INSTALLMENT NO. 12

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*This index is revised monthly as additional tables are published.
[1]In footage, "feet" should read "inches."
[2]Headings "Redwood No. 1 seconds" and "Redwood admiralty seconds" should be transposed.

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CLEARANCE BETWEEN BITS AND CASING OF VARIOUS SIZES, IN.

Casing specifications				Standard bit sizes		
A.P.I. casing size, O. D., in.	Casing coupling diam., O.D.. in.	Wt. per ft. with couplings, lb.	I.D., in.	Bit or reamer size, in.	Clearance, in.	
					Thousandths	Nearest 64th
4 3/4	5.364	16.25	4.082	3 7/8	.207	13/64
4 3/4	5.364	16	4.082	3 7/8	.207	13/64
5 1/4	6.5625	14	5.290	4 1/4	1.040	1 1/32
5 3/4	6.5625	23	4.990	4 3/4	.240	15/64
5 3/4	6.5625	22 5	4.990	4 3/4	.240	15/64
5 3/4	6.5625	19.5	5.090	4 3/4	.340	1/4
5 3/4	6.5625	17	5.190	4 3/4	.440	7/16
5 3/4	6.5625	14	5.290	4 3/4	.540	35/64
*6 5/8	7.39	29.2	5.761	5 5/8	.136	9/64
6 5/8	7.39	28	5.791	5 5/8	.166	11/64
*6 5/8	7.39	27	5.839	5 5/8	.214	7/32
6 5/8	7.39	26	5.855	5 5/8	.230	15/64
6 5/8	7.39	24	5.921	5 5/8	.296	19/64
6 5/8	7.39	20	6.049	5 7/8	.174	11/64
7	7.656	30	6.154	5 7/8	.279	9/32
7	7.656	28	6.214	5 7/8	.339	11/32
7	7.656	30	6.154	6	.154	5/32
7	7.656	28	6.214	6	.214	7/32
7	7.656	26	6.276	6	.276	9/32
7	7.656	24	6.336	6	.336	11/32
7	7.656	22	6.398	6	.398	13/32
7	7.656	20	6.456	6	.456	15/32
7	7.656	26	6.276	6 1/8	.151	5/32
7	7.656	24	6.336	6 1/8	.211	7/32
7	7.656	22	6.398	6 1/8	.273	13/64
7	7.656	20	6.456	6 1/8	.331	21/64
7 5/8	8.5	33.7	6.765	6 1/2	.265	1/4
7 5/8	8.5	29.7	6.875	6 1/2	.375	3/8
7 5/8	8.5	26.4	6.969	6 1/2	.469	15/32
7 5/8	8.5	33.7	6.765	6 3/4	.015	1/64
7 5/8	8.5	29.7	6.875	6 3/4	.125	1/8
7 5/8	8.5	26.4	6.969	6 3/4	.219	7/32
8 1/8	9.0931	40	7.185	6 3/4	.435	7/16
8 1/8	9.0931	39.5	7.185	6 3/4	.435	7/16
8 1/8	9.0931	35.5	7.285	6 3/4	.535	17/32
8 1/8	9.0931	32	7.385	6 3/4	.635	5/8
8 1/8	9.0931	28	7.485	6 3/4	.735	47/64
8 1/8	9.0931	40	7.185	7	.185	3/16
8 1/8	9.0931	39.5	7.185	7	.185	3/16
8 1/8	9.0931	35.5	7.285	7	.285	9/32
8 1/8	9.0931	32	7.385	7	.385	3/8
8 1/8	9.0931	28	7.485	7	.485	1/2
8 5/8	9.593	43	7.651	7 1/2	.151	5/32
8 5/8	9.593	38	7.775	7 5/8	.150	5/32
8 5/8	9.593	36	7.825	7 5/8	.200	13/64
8 5/8	9.593	32	7.921	7 5/8	.296	19/64
8 5/8	9.593	28	8.017	7 5/8	.392	25/64
*9	10.01	54	7.812	7 5/8	.187	3/16
9	10.01	45	8.032	7 7/8	.157	5/32
9	10.01	40	8.150	7 7/8	.275	9/32
9	10.01	38	8.196	7 7/8	.321	5/16
9	10.01	34	8.290	7 7/8	.415	27/64

Casing specifications				Standard bit sizes		
A.P.I. casing size, O. D., in.	Casing coupling diam., O.D.. in.	Wt. per ft. with couplings, lb.	I.D., in.	Bit or reamer size, in.	Clearance, in.	
					Thousandths	Nearest 64th
*9 5/8	10.625	47.2	8.681	8 3/8	.306	5/16
*9 5/8	10.625	43.5	8.755	8 3/8	.380	3/8
*9 5/8	10.625	40	8.835	8 3/8	.460	15/32
9 5/8	10.625	36	8.921	8 3/8	.546	9/16
*9 5/8	10.625	47.2	8.681	8 5/8	.056	1/16
*9 5/8	10.625	43.5	8.755	8 5/8	.130	1/8
*9 5/8	10.625	40	8.835	8 5/8	.210	13/64
9 5/8	10.625	36	8.921	8 5/8	.296	19/64
10 3/4	11.75	55.5	9.760	9 5/8	.135	1/8
10 3/4	11.75	51	9.850	9 5/8	.225	7/32
10 3/4	11.75	45.5	9.950	9 5/8	.325	21/64
10 3/4	11.75	40.5	10.050	9 7/8	.175	11/64
11 3/4	12.866	60	10.772	10 5/8	.147	1/8
11 3/4	12.866	54	10.880	10 5/8	.255	1/4
11 3/4	12.866	47	11.000	10 5/8	.375	3/8
13 3/8	14.375	68	12.415	11	1.415	1 13/32
13 3/8	14.375	61	12.515	11	1.515	1 1/2
13 3/8	14.375	54.5	12.615	11	1.615	1 5/8
13 3/8	14.375	48	12.715	11	1.715	1 23/32
13 3/8	14.375	68	12.415	12 1/4	.165	11/64
13 3/8	14.375	61	12.515	12 1/4	.265	17/64
13 3/8	14.375	54.5	12.615	12 1/4	.365	23/64
13 3/8	14.375	48	12.715	12 1/4	.465	15/32
16	17	84	15.010	13 3/4	1.260	1 1/4
16	17	75	15.125	13 3/4	1.375	1 3/8
16	17	65	15.250	13 3/4	1.500	1 1/2
16	17	55	15.375	13 3/4	1.625	1 5/8
16	17	84	15.010	14 3/4	.260	17/64
16	17	75	15.125	14 3/4	.375	3/8
16	17	65	15.250	14 3/4	.500	1/2
16	17	55	15.375	14 3/4	.625	5/8
18 5/8	19.75	96.5	17.655	15 1/2	2.155	2 5/32
18 5/8	19.75	87.5	17.755	15 1/2	2.255	2 1/4
18 5/8	19.75	78	17.855	15 1/2	2.355	2 11/32
18 5/8	19.75	96.5	17.655	17	.655	21/32
18 5/8	19.75	87.5	17.755	17	.755	3/4
18 5/8	19.75	78	17.855	17	.855	27/32
18 5/8	19.75	96.5	17.655	17 1/2	.155	5/32
18 5/8	19.75	87.5	17.755	17 1/2	.255	1/4
18 5/8	19.75	78	17.855	17 1/2	.355	23/64
21 1/2	22.625	114	20.510	18 5/8	1.885	1 7/8
21 1/2	22.625	103	20.610	18 5/8	1.985	2
21 1/2	22.625	92.5	20.710	18 5/8	2.085	2 3/32
21 1/2	22.625	114	20.510	20	.510	1/2
21 1/2	22.625	103	20.610	20	.610	39/64
21 1/2	22.625	92.5	20.710	20	.710	45/64
24 1/2	25.625	113	23.650	20 3/4	2.900	2 29/32
24 1/2	25.625	100.5	23.750	20 3/4	3.000	3
24 1/2	25.625	113	23.650	23	.650	5/8
24 1/2	25.625	100.5	23.750	23	.750	3/4

*Non A.P.I.

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WEIGHT AND VOLUME OF 3½-IN. DRILL PIPE

Length of string of drill pipe, ft.	8.50 lb. drill pipe				11.20 lb. drill pipe				13.30 lb. drill pipe			
	Weight, coupled,[1] lb.	Volume of fluid displaced, gal.	Weight of 9.5 lb./gal. fluid displaced, lb.	Net weight of drill pipe, lb.	Weight, coupled,[1] lb.	Volume of fluid displaced, gal.	Weight of 9.5 lb./gal. fluid displaced, lb.	Net weight of drill pipe, lb.	Weight, coupled,[1] lb.	Volume of fluid displaced, gal.	Weight of 9.5 lb./gal. fluid displaced, lb.	Net weight of drill pipe, lb.
2,000	17,000	259.8	2,470	14,530	22,400	342.2	3,250	19,150	26,600	406.4	3,860	22,740
2,200	18,700	285.8	2,715	15,985	24,640	376.4	3,575	21,065	29,260	447.0	4,245	25,015
2,400	20,400	311.8	2,960	17,440	26,880	410.6	3,900	22,980	31,920	487.7	4,635	27,285
2,600	22,100	337.7	3,210	18,890	29,120	444.9	4,225	24,895	34,580	528.3	5,020	29,560
2,800	23,800	363.7	3,455	20,345	31,360	479.1	4,550	26 810	37,240	569.0	5,405	31,835
3,000	25,500	389.7	3,700	21,800	33,600	513.3	4,875	28,725	39,900	609.6	5,790	34,110
3,200	27,200	415.7	3,950	23,250	35,840	547.5	5,200	30,640	42 560	650.2	6,175	36,385
3,400	28,900	441.7	4,195	24,705	38,080	581.7	5,525	32,555	45,220	690.9	6,565	38,655
3,600	30,600	467.6	4,445	26,155	40,320	616.0	5,850	34,470	47,880	731.5	6,950	40,930
3,800	32,300	493.6	4,690	27,610	42,560	650.2	6,175	36,385	50,540	772.7	7,335	43,205
4,000	34,000	519.6	4,935	29,065	44,800	684.4	6,500	38,300	53,200	812.8	7,720	45,480
4,200	35,700	545.6	5,185	30,515	47,040	718.6	6,825	40,215	55,860	853.4	8,110	47,750
4,400	37,400	571.6	5,430	31,970	49,280	752.8	7,150	42,130	58,520	894.1	8,495	50,025
4,600	39,100	597.5	5,675	33,425	51,520	787.1	7,475	44,045	61,180	934.7	8,880	52 300
4,800	40,800	623.5	5,925	34,875	53,760	821.3	7,800	45,960	63,840	975.4	9,265	54,575
5,000	42,500	649.5	6,170	36,330	56,000	855.5	8,125	47 875	66,500	1016.0	9,650	56,850
5,200	44,200	675.5	6,415	37,785	58,240	889.7	8,450	49,790	69,160	1056.6	10,040	59,120
5,400	45,900	701.5	6,665	39,235	60.480	923.9	8,775	51,705	71,820	1097.3	10,425	61,395
5,600	47,600	727.4	6,910	40,690	62,720	958.2	9,105	53,615	74,480	1137.9	10,810	63,670
5,800	49,300	753.4	7,155	42,145	64,960	992.4	9,430	55,530	77,140	1178.6	11,195	65,945
6,000	51,000	779.4	7,405	43,595	67,200	1026.6	9,755	57,445	79,800	1219.2	11,580	68,220
6,200	52,700	805.4	7,650	45,050	69,440	1060.8	10,080	59,360	82,460	1259.8	11,970	70,490
6,400	54,400	831.4	7,900	46,500	71,680	1095.0	10,405	61,275	85,120	1300.5	12,355	72,765
6,600	56,100	857.3	8,145	47,955	73,920	1129.3	10,730	63,190	87,780	1341.1	12,740	75,040
6,800	57,800	883.3	8,390	49,410	76,160	1163.5	11,055	65,105	90,440	1381.8	13,125	77.315
7,000	59,500	909.3	8,640	50,860	78,400	1197.7	11,380	67,020	93,100	1422.4	13,515	79,585
7,200	61,200	935.3	8,885	52,315	80,640	1231.9	11,705	68,935	95,760	1463.0	13,900	81,860
7,400	62,900	961.3	9,130	53,770	82,880	1266.1	12,030	70,850	98,420	1503.7	14,285	84,135
7,600	64,600	987.2	9,380	55,220	85,120	1300.4	12,355	72,765	101,080	1544.3	14,670	86,410
7,800	66,300	1013.2	9,625	56,675	87,360	1334.6	12,680	74,680	103,740	1585.0	15,055	88.685
8,000	68,000	1039.2	9,870	58,130	89,600	1368.8	13,005	76,595	106,400	1625.6	15,445	90,955
8,200	69,700	1065.2	10,120	59,580	91,840	1403.0	13,330	78,510	109,060	1666.2	15,830	93,230
8,400	71,400	1091.2	10,365	61,035	94,080	1437.2	13,655	80,425	111,720	1706.9	16,215	95,505
8,600	73,100	1117.1	10,615	62,485	96,320	1471.5	13,980	82,340	114,380	1747.5	16,600	97,780
8,800	74,800	1143.1	10,860	63,940	98,560	1505.7	14,305	84,255	117,040	1788.2	16,990	100,050
9,000	76,500	1169.1	11,105	65,395	100,800	1539.9	14,630	86,170	119,700	1828.8	17,375	102,325
9,200	78,200	1195.1	11,355	66,845	103,040	1574.1	14,955	88,085	122,360	1869.4	17,760	104,600
9,400	79,900	1221.1	11,600	68,300	105,280	1608.3	15,280	90,000	125,020	1910.1	18,145	106,875
9,600	81,600	1247.0	11,845	69,755	107,520	1642.6	15,605	91,915	127,680	1950.7	18,530	109,150
9,800	83,300	1273.0	12,095	71,205	109,760	1676.8	15,930	93,830	130,340	1991.4	18,920	111,420
10,000	85,000	1299.0	12,340	72,660	112,000	1711.0	16,255	95 745	133,000	2032.0	19,305	113,695
10,200	86,700	1325.0	12,585	74,115	114,240	1745.2	16,580	97,660	135,660	2072.6	19,690	115,970
10,400	88,400	1351.0	12,835	75,565	116,480	1779.4	16,905	99,575	138,320	2113.3	20,075	118,245
10,600	90,100	1376.9	13,080	77,020	118,720	1813.7	17,230	101,490	140,980	2153.9	20,460	120,520
10,800	91,800	1402.9	13,330	78,470	120,960	1847.9	17,555	103,405	143,640	2194.6	20,850	122,790
11,000	93,500	1428.9	13,575	79,925	123,200	1882.1	17,880	105,320	146,300	2235.2	21,235	125,065
11,200	95,200	1454.9	13,820	81,380	125,440	1916.3	18,205	107,235	148,960	2275.8	21,620	127,340
11,400	96,900	1480.9	14,070	82,830	127,680	1950.5	18,530	109,150	151,620	2316.5	22,005	129,615
11,600	98,600	1506.8	14,315	84,285	129,920	1984.8	18,855	111,065	154,280	2357.1	22,395	131,885
11,800	100,300	1532.8	14,560	85,740	132,160	2019.0	19,180	112,980	156,940	2397.8	22,780	134,160
12,000	102,000	1558.8	14,810	87,190	134,400	2053.2	19,505	114,895	159,600	2438.4	23,165	136,435
12,200	103,700	1584.8	15,055	88,645	136,640	2087.4	19,830	116,810	162,260	2479.0	23,550	138,710
12,400	105,400	1610.8	15,300	90,100	138,880	2121.6	20,155	118,725	164,920	2519.7	23,935	140,985
12,600	107,100	1636.7	15,550	91,550	141,120	2155.9	20,480	120,640	167,580	2560.3	24,325	143,255
12,800	108,800	1662.7	15,795	93,005	143,360	2190.1	20,805	122,555	170,240	2601.0	24,710	145,530
13,000	110,500	1688.7	16,045	94,455	145,600	2224.3	21,130	124,470	172,900	2641.6	25,095	147,805

[1]If a regular tool joint is inserted every 90 ft. all values for 8.50-lb. drill pipe will be increased about 2.4 percent, for 11.20-lb. drill pipe about 1.6 percent, and for 13.30-lb. drill pipe about 1.2 percent.

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VOLUME, CU. FT. PER 100 FT., OF ANNULAR SPACE BETWEEN CASING AND WALL OF WELL

Diameter[1] of drill hole, in.	Diameter of casing, O. D., in.																										
	4¾	5	5½	5¾	6	6⅝	7	7⅝	8	8⅛	8⅝	9	9⅝	10	10¾	11¾	12	13	13⅜	14	16	18⅝	20	21½	24½
6	7.6	6.2																							
6½	11.1	9.7	6.2																						
7	14.6	13.2	10.4	8.3	6.9																				
7½	18.1	17.4	13.9	12.5	11.1	6.9	8.3																		
8	22.9	21.5	18.1	16.7	15.3	11.1	12.5																		
8½	27.1	25.7	22.9	21.5	19.4	15.3	17.4	12.5	9.0																
9	31.9	30.6	27.8	26.4	24.3	20.1	22.2	17.4	14.6	13.2															
9½	36.8	35.4	32.6	31.2	29.9	25.0	27.8	22.9	19.4	18.7	13.9														
10	42.4	41.0	38.2	36.1	34.7	30.6	33.3	28.5	25.0	24.3	19.4	16.0													
10½	47.9	46.5	43.7	42.4	40.3	36.1	38.9	34.0	31.2	29.9	25.7	21.5	15.3												
11	53.5	52.1	49.3	47.9	46.5	41.7	45.1	40.3	37.5	36.1	31.9	27.8	21.5	17.4											
11½	59.7	58.3	55.6	54.2	52.8	47.9	52.1	46.5	43.7	42.4	38.2	34.7	27.8	24.3	15.3										
12	66.0	65.3	61.8	60.4	59.0	54.9	58.3	53.5	50.0	49.3	44.4	41.0	34.7	30.6	22.2										
12½	72.9	71.5	68.7	67.4	65.3	61.1	65.3	60.4	56.9	56.2	51.4	47.9	41.7	37.5	29.2	16.7									
13	79.9	78.5	75.7	74.3	72.2	68.1	72.9	67.4	64.6	63.2	59.0	55.6	48.6	45.1	36.1	24.3	20.8								
13½	86.8	86.1	82.6	81.2	79.9	75.7	79.9	75.0	72.2	70.8	66.7	62.5	56.2	52.1	43.7	31.9	28.5	17.4							
14	94.4	93.1	90.3	88.9	87.5	82.6	86.9	82.6	79.9	78.5	74.3	70.8	63.9	60.4	51.4	39.6	36.1	22.2	25.0						
14½	102.1	101.4	97.9	96.5	95.1	91.0	95.8	91.0	87.5	86.8	81.9	78.5	72 2	68.1	59.7	47.2	44.4	30.6	33.3	24.3					
15	110.4	109.0	106.2	104.9	102.8	98.6	104.2	99.3	95.8	95.1	90.3	86.8	80.6	76.4	68.1	55.6	52.8	38.9	42.4	32.6					
15½	118.7	117.4	114.6	113.2	111.1	106.9	113.2	107.6	104.9	103.5	99.3	95.8	88.9	85.4	76.4	64.6	61.1	47.2	50.7	40.7					
16	127.1	126.4	122.9	121.5	120.1	116.0	113.2	125.7	122.9	121.5	117.4	113.2	106.9	102.8	94.4	82.6	79.2	65.3	59.7	50.7	36.8				
17	145.1	143.7	141.0	139.6	138.2	133.3	130.6	125.7	122.9	121.5	117.4	113.2	106.9	102.8	94.4	82.6	79.2	65.3	59.7	50.7	36.8				
18	164.6	163.2	160.4	158.3	156.9	152.8	150.0	145.1	141.7	141.0	136.1	132.6	126.4	122.2	113.9	101.4	97.9	84.7	79.2	70.1	56.9	29.2			
19	184.7	183.3	180.6	179.2	177.1	172.9	170.1	165.3	161.8	161.1	156.2	152.8	146.5	142.4	134.0	121.5	118.1	104.9	99.3	90.3	56.9	29.2			
20	205.6	204.9	201.4	200.0	198.6	194.4	191.7	186.1	183.3	181.9	177.8	174.3	167.4	163.9	154.9	143.1	139.6	126.4	120.8	111.1	78.5	51.4	45.8		
21	228.5	227.1	224.3	222.2	220.8	216.7	213.9	209.0	205.6	204.9	200.0	196.5	190.3	186.1	177.8	165.3	161.8	148.6	143.1	133.3	100.7	75.0	45.8		
22	251.4	250.0	247.2	245.8	244.4	240.3	237.5	231.9	229.2	227.8	223.6	219.4	213.2	209.7	200.7	188.9	185.4	171.5	166.7	156.9	124.3	99.3	70.1	36.1	
23	276.4	275.0	272.2	270.8	268.7	264.6	261.8	256.9	253.5	252.8	247.9	244.4	238.2	234.0	225.7	213.2	209.7	196.5	191.0	181.9	148.6	123.6	95.8	61.8	
24	302.1	300.7	297.9	295.8	294.4	290.3	287.5	282.6	279.2	278.5	273.6	270.1	263.9	259.7	251.4	238.9	235.4	222.2	216.7	206.9	174.3	125.0	95.8	88.9	
25	328.5	327.1	324.3	322.9	321.5	316.7	313.9	309.0	306.2	304.9	300.0	296.5	290.3	286.1	277.8	265.3	262.5	248.6	243.1	234.0	201.4	151.4	122.9	88.9	
26						344.4	341.7	336.8	334.0	332.6	327.8	324.3	318.1	313.9	305.6	293.1	290.3	276.4	270.8	261.8	229.2	179.2	150.7	117.4	41.7
27													347.2	343.1	334.7	322.2	319.4	305.6	300.0	291.0	258.3	208.3	179.2	145.8	70.1
28																		335.4	329.9	320.8	288.2	238.2	209.7	175.7	100.0
29																				352.1	318.7	269.4	240.3	206.2	131.2
30																					351.4	301.4	272.9	238.9	163.9
31																					384.7	334.7	306.2	272.2	196.5
32																					418.7	369.4	340.3	306.2	231.2
33																						404.9	375.7	341.7	266.7
34																						441.7	412.5	378.5	302.8
35																						479.2	445.0	416.0	341.0
36																						518.1	488.9	454.9	379.2

[1] In estimating this value the user of the table is cautioned to make sufficient allowance, based on his knowledge of drilling conditions, for caving, sloughing, etc.

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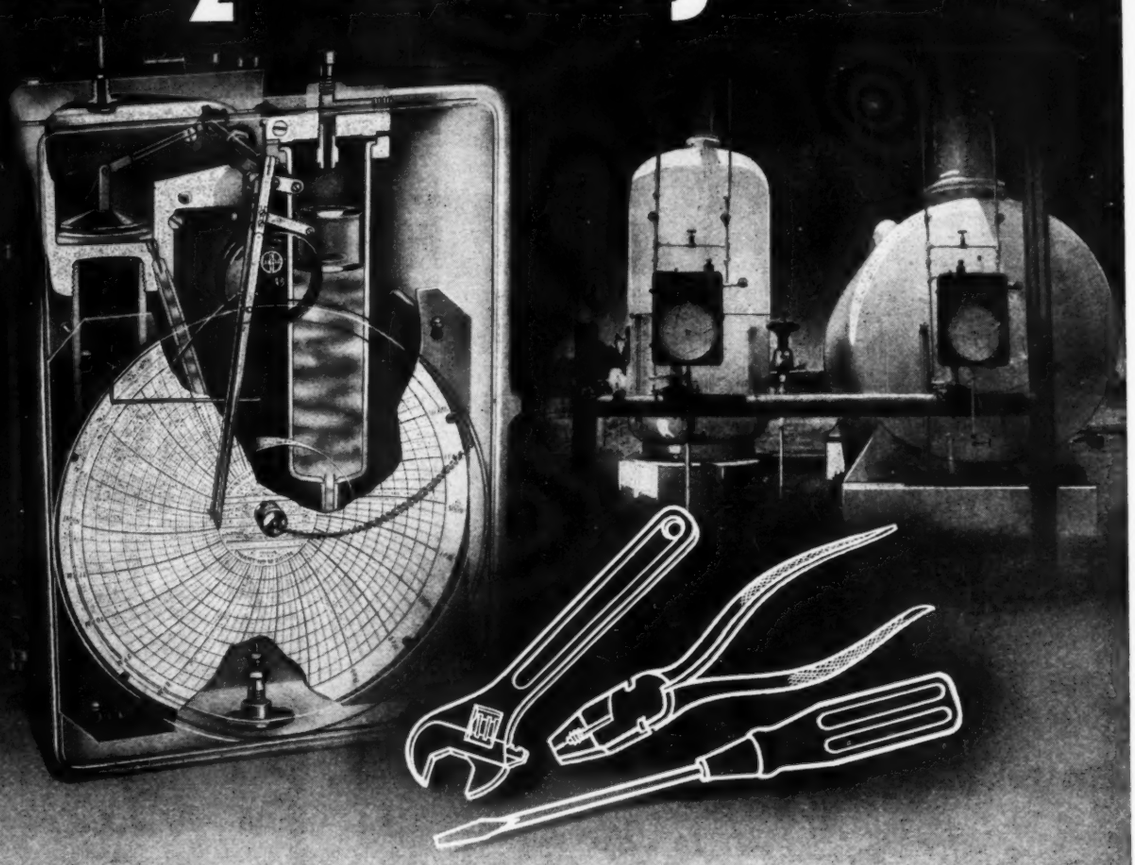
VAPORIZATION EQUILIBRIUM CONSTANTS[1] (K-VALUES) OF n-HEXANE

Temperature, deg. fahr.	Pressure, lb. per sq. in. abs.																			
	10	14.7	20	30	40	50	60	70	80	90	100	120	140	160	180	200	250	300	400	500
40	.125	.09	.066	.046	.036	.030	.026	.023	.021	.020	.019	.017	.015	.014	.013	.012	.011	.010		
60	.210	.15	.110	.078	.060	.050	.044	.039	.035	.033	.031	.028	.024	.022	.021	.020	.018	.016	.015	.014
80	.335	.24	.175	.125	.096	.080	.070	.061	.056	.052	.049	.043	.039	.036	.033	.031	.028	.025	.023	.021
100	.50	.36	.260	.180	.14	.115	.100	.090	.083	.077	.072	.063	.057	.053	.050	.047	.041	.037	.034	.031
120	.74	.52	.385	.265	.21	.170	.150	.130	.12	.110	.105	.092	.082	.077	.072	.067	.059	.054	.049	.045
140	1.05	.76	.56	.38	.30	.245	.215	.185	.17	.155	.145	.13	.115	.110	.100	.097	.085	.078	.069	.064
160	1.50	1.05	.79	.54	.42	.34	.295	.26	.24	.215	.20	.18	.160	.150	.140	.13	.115	.105	.095	.086
180	2.1	1.45	1.10	.75	.58	.47	.41	.36	.32	.30	.27	.24	.215	.205	.190	.18	.160	.145	.130	.115
200	2.8	1.95	1.45	1.00	.78	.62	.54	.47	.43	.39	.36	.32	.285	.265	.245	.23	.205	.19	.165	.155
220	3.6	2.5	1.95	1.30	1.0	.82	.70	.60	.55	.50	.46	.41	.36	.34	.315	.30	.265	.24	.215	.195
240	4.6	3.2	2.45	1.65	1.3	1.05	.89	.77	.69	.63	.58	.51	.45	.42	.39	.37	.33	.30	.265	.245
260	5.8	4.1	3.1	2.10	1.6	1.30	1.10	.96	.86	.78	.72	.64	.56	.52	.48	.46	.40	.37	.33	.310
280	7.2	5.0	3.8	2.60	2.0	1.60	1.35	1.15	1.05	.96	.88	.78	.68	.63	.58	.55	.48	.44	.40	.375
300	8.8	6.1	4.6	3.15	2.4	1.95	1.65	1.40	1.25	1.15	1.05	.92	.82	.75	.69	.65	.57	.52	.47	.440
320	10.5	7.3	5.5	3.70	2.8	2.3	1.95	1.65	1.50	1.35	1.25	1.08	.96	.87	.80	.76	.67	.60	.54	.505
340	12.2	8.5	6.4	4.30	3.3	2.7	2.25	1.95	1.75	1.55	1.45	1.23	1.10	1.00	.92	.87	.76	.69	.62	.57
360	14.0	9.8	7.4	5.95	3.8	3.1	2.60	2.25	2.00	1.80	1.65	1.40	1.25	1.15	1.05	.99	.86	.78	.70	.65
380	16.0	11.0	8.4	5.6	4.3	3.5	2.95	2.50	2.25	2.05	1.85	1.60	1.40	1.30	1.20	1.12	.96	.87	.77	.72
400	17.5	12.5	9.2	6.3	4.8	3.9	3.30	2.75	2.5	2.25	2.05	1.75	1.60	1.45	1.35	1.25	1.05	.96	.85	.79
420	19.0	13.5	10.0	6.8	5.2	4.2	3.60	3.00	2.7	2.45	2.25	1.90	1.70	1.6	1.45	1.35	1.15	1.05	.93	.86
440	20.5	14.5	10.8	7.3	5.6	4.5	3.85	3.25	2.9	2.65	2.40	2.15	1.85	1.7	1.55	1.45	1.25	1.12	1.00	.93
460	22.0	15.5	11.5	7.8	6.0	4.8	4.10	3.50	3.1	2.85	2.60	2.20	2.00	1.8	1.65	1.55	1.35	1.20	1.08	.99
480	23.5	16.5	12.2	8.3	6.4	5.2	4.35	3.75	3.3	3.00	2.75	2.35	2.10	1.9	1.75	1.65	1.42	1.28	1.15	1.05
500	25.0	17.5	13.0	8.8	6.8	5.5	4.60	4.00	3.5	3.15	2.90	2.50	2.20	2.0	1.85	1.75	1.50	1.35	1.22	1.10
520	26.5	18.5	13.8	9.3	7.2	5.8	4.85	4.2	3.7	3.30	3.10	2.65	2.30	2.1	1.95	1.85	1.60	1.42	1.30	1.15
540	28.0	19.5	14.5	9.9	7.6	6.1	5.10	4.4	3.9	3.45	3.25	2.80	2.40	2.2	2.05	1.95	1.68	1.50	1.35	1.20
560	29.5	20.5	15.2	10.5	8.0	6.4	5.35	4.6	4.1	3.65	3.40	2.95	2.55	2.3	2.15	2.05	1.75	1.58	1.40	1.25
580	31.0	21.5	16.0	11.0	8.4	6.7	5.60	4.8	4.3	3.85	3.55	3.10	2.70	2.4	2.30	2.15	1.85	1.65	1.48	1.32
600	32.5	23.0	16.8	11.5	8.8	7.0	5.90	5.1	4.5	4.05	3.75	3.25	2.85	2.5	2.40	2.25	1.95	1.72	1.55	1.40
620	34.0	24.0	17.5	12.0	9.2	7.4	6.20	5.4	4.7	4.25	3.95	3.40	3.00	2.6	2.50	2.35	2.05	1.80	1.62	1.48
640	35.5	25.0	18.5	12.5	9.6	7.8	6.55	5.6	5.0	4.45	4.15	3.55	3.15	2.8	2.60	2.45	2.15	1.90	1.70	1.55
660	37.5	26.5	19.5	13.2	10.0	8.2	6.90	5.9	5.2	4.65	4.35	3.75	3.30	3.0	2.75	2.55	2.25	2.00	1.80	1.62
680	39.5	27.5	20.5	14.0	10.5	8.6	7.25	6.2	5.5	4.90	4.55	3.95	3.45	3.1	2.90	2.70	2.35	2.10	1.9	1.7
700	41.5	29.0	21.5	14.8	11.0	9.0	7.60	6.5	5.8	5.25	4.75	4.15	3.65	3.2	3.05	2.85	2.45	2.20	2.0	1.8
720	43.5	30.5	22.8	15.5	12.0	9.5	8.00	6.8	6.1	5.4	5.0	4.35	3.85	3.4	3.20	3.00	2.55	2.30	2.1	1.9
740	46.0	32.0	24.0	16.2	12.5	10.0	8.45	7.2	6.4	5.7	5.3	4.55	4.05	3.6	3.35	3.15	2.70	2.40	2.2	2.0
760	48.5	34.0	25.0	17.0	13.0	10.5	8.90	7.6	6.7	6.0	5.6	4.80	4.25	3.8	3.5	3.3	2.85	2.55	2.3	2.1
780	51.0	35.5	26.2	17.8	13.8	11.0	9.35	7.9	7.0	6.3	5.9	5.05	4.45	4.0	3.7	3.5	3.00	2.70	2.4	2.2
800	54.0	37.0	27.5	18.5	14.5	11.5	9.80	8.3	7.4	6.6	6.2	5.30	4.65	4.2	3.9	3.7	3.15	2.85	2.5	2.3

[1]From curve showing equilibrium constants for n-Hexane prepared by George Granger Brown, Ann Arbor, Michigan, by permission.

Easy to adjust



out in the field

LET'S SEE HOW EASY it is to adjust a Westcott Orifice Meter! The door of the dust-and-moisture-proof aluminum case merely is swung open . . . exposing pressure spring, clock, chart, and recording mechanism. Or, by speedily removing the low-pressure chamber cover of the forged-steel differential gage body, the entire interior is accessible . . . without loosening a single connection that affects accuracy. Adjustments do not interfere with any of the working parts . . . few in number and simple in design, despite their many features and refinements.

Comprehensive literature describes the expense-saving Westcott Orifice Meters and Flowmeters . . . clearly defines their applications. Specifications on the popular new Round Case Indicating Flowmeters also will be mailed on request.

AMERICAN METER CO.

343

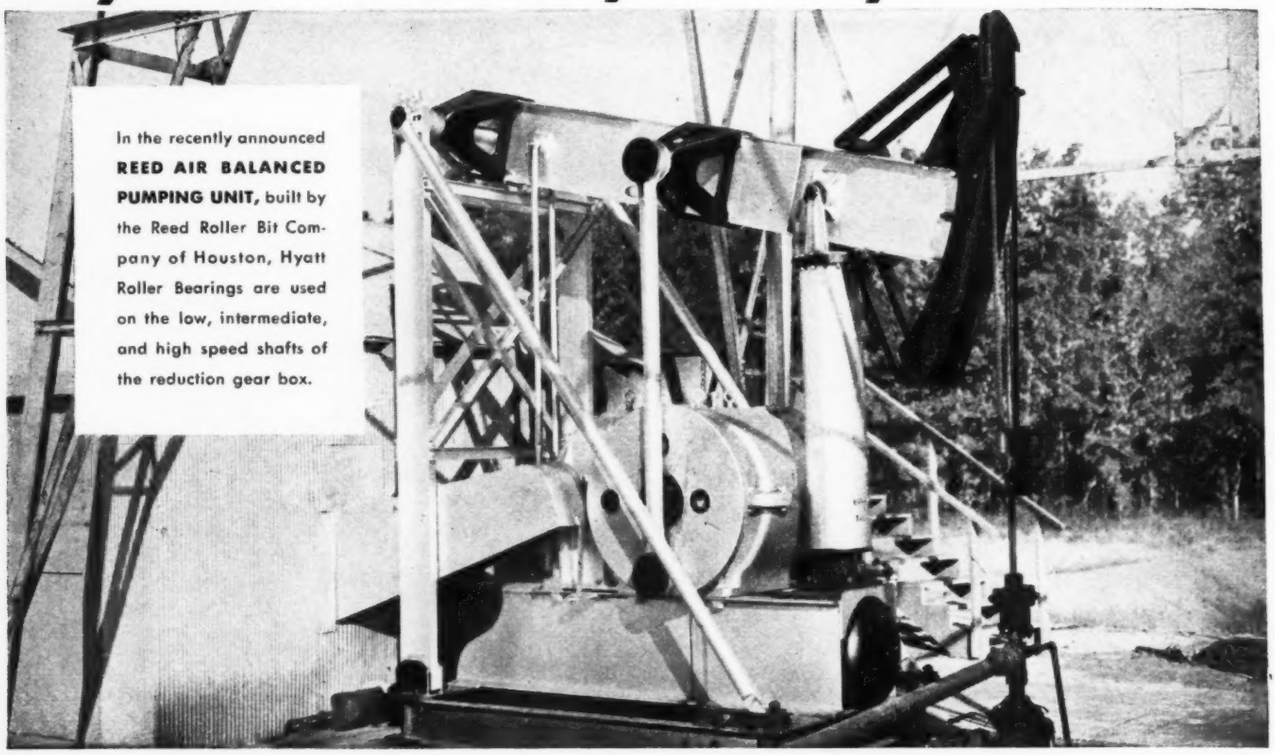
AMERICAN METER COMPANY
INCORPORATED
Measurement and control of Gas, Oil, Steam, Air and Liquids
METRIC METAL WORKS *ERIE, PENNSYLVANIA*

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH 3½-IN. PLAIN TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	1000	8.5	3.2	2.0	1.4	1.1	0.9	0.8	0.7	0.6
100		17.0	6.3	3.9	2.9	2.3	1.9	1.6	1.4	1.2
150		25.4	9.5	5.9	4.3	3.4	2.8	2.4	2.1	1.9
200		33.9	12.7	7.9	5.7	4.5	3.7	3.2	2.8	2.5
250		42.4	15.8	9.8	7.1	5.6	4.7	4.0	3.5	3.1
300		50.9	19.0	11.8	8.6	6.8	5.6	4.8	4.2	3.7
350		59.3	22.2	13.7	10.0	7.9	6.5	5.6	4.9	4.4
400		67.8	25.4	15.7	11.4	9.0	7.5	6.4	5.6	5.0
50	1250	10.6	3.9	2.4	1.8	1.4	1.2	1.0	0.9	0.8
100		21.2	7.9	4.9	3.5	2.8	2.3	2.0	1.7	1.5
150		31.8	11.8	7.3	5.3	4.2	3.5	3.0	2.6	2.3
200		42.3	15.8	9.8	7.1	5.6	4.6	4.0	3.5	3.1
250		52.9	19.7	12.2	8.9	7.0	5.8	4.9	4.3	3.8
300		63.5	23.7	14.6	10.6	8.4	6.9	5.9	5.2	4.6
350		74.1	27.6	17.1	12.4	9.8	8.1	6.9	6.0	5.4
400		84.7	31.6	19.5	14.2	11.2	9.2	7.9	6.9	6.2
50	1500	12.7	4.7	2.9	2.1	1.7	1.4	1.2	1.0	0.9
100		25.4	9.5	5.8	4.2	3.3	2.8	2.4	2.1	1.8
150		38.1	14.2	8.8	6.4	5.0	4.1	3.5	3.1	2.7
200		50.8	18.9	11.7	8.5	6.7	5.5	4.7	4.1	3.7
250		63.5	23.6	14.6	10.6	8.3	6.9	5.9	5.1	4.6
300		76.2	28.4	17.5	12.7	10.0	8.3	7.1	6.2	5.5
350		88.8	33.1	20.4	14.8	11.7	9.6	8.2	7.2	6.4
400		101.5	37.8	23.4	17.0	13.3	11.0	9.4	8.2	7.3
50	1750	14.8	5.5	3.4	2.5	1.9	1.6	1.4	1.2	1.1
100		29.6	11.0	6.8	4.9	3.9	3.2	2.7	2.4	2.1
150		44.4	16.5	10.2	7.4	5.8	4.8	4.1	3.6	3.2
200		59.2	22.0	13.6	9.9	7.8	6.4	5.5	4.8	4.2
250		74.0	27.5	17.0	12.3	9.7	8.0	6.8	6.0	5.3
300		88.8	33.1	20.4	14.8	11.6	9.6	8.2	7.1	6.3
350		103.6	38.6	23.8	17.3	13.6	11.2	9.5	8.3	7.4
400		118.4	44.1	27.2	19.7	15.5	12.8	10.9	9.5	8.5
50	2000	16.9	6.3	3.9	2.8	2.2	1.8	1.6	1.4	1.2
100		33.8	12.6	7.8	5.6	4.4	3.6	3.1	2.7	2.4
150		50.7	18.9	11.6	8.4	6.6	5.5	4.7	4.1	3.6
200		67.6	25.2	15.5	11.2	8.8	7.3	6.2	5.4	4.8
250		84.5	31.5	19.4	14.1	11.0	9.1	7.8	6.8	6.0
300		101.4	37.7	23.3	16.9	13.2	10.9	9.3	8.1	7.2
350		118.4	44.0	27.1	19.7	15.5	12.8	10.9	9.5	8.4
400		135.3	50.3	31.0	22.5	17.7	14.6	12.4	10.8	9.6
50	2250	19.0	7.1	4.4	3.2	2.5	2.0	1.7	1.5	1.3
100		38.0	14.1	8.7	6.3	5.0	4.1	3.5	3.0	2.7
150		57.0	21.2	13.1	9.5	7.4	6.1	5.2	4.6	4.0
200		76.1	28.3	17.4	12.6	9.9	8.2	7.0	6.1	5.4
250		95.1	35.4	21.8	15.8	12.4	10.2	8.7	7.6	6.7
300		114.1	42.4	26.1	18.9	14.9	12.3	10.4	9.1	8.1
350		133.1	49.5	30.5	22.1	17.3	14.3	12.2	10.6	9.4
400		152.1	56.6	34.9	25.2	19.8	16.3	13.9	12.1	10.8
50	2500	21.1	7.9	4.8	3.5	2.7	2.3	1.9	1.7	1.5
100		42.2	15.7	9.7	7.0	5.5	4.5	3.9	3.4	3.0
150		63.4	23.6	14.5	10.5	8.2	6.8	5.8	5.0	4.5
200		84.5	31.4	19.3	14.0	11.0	9.1	7.7	6.7	6.0
250		105.6	39.3	24.2	17.5	13.7	11.3	9.6	8.4	7.5
300		126.7	47.1	29.0	21.0	16.5	13.6	11.6	10.1	8.9
350		147.9	55.0	33.8	24.5	19.2	15.9	13.5	11.8	10.4
400		169.0	62.8	38.7	28.0	22.0	18.1	15.4	13.4	11.9

[1]Solution and condensation under pressure are not considered; hence the values are maxima.

Higher and Higher Speeds...

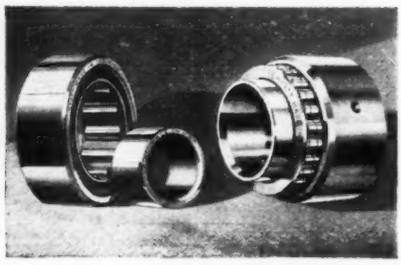


In the recently announced **REED AIR BALANCED PUMPING UNIT,** built by the Reed Roller Bit Company of Houston, Hyatt Roller Bearings are used on the low, intermediate, and high speed shafts of the reduction gear box.

...call for HYATTS

THE insistent demand today is for faster production and higher speeds. And higher speeds, in turn, make their own demands — for increased smoothness, for decreased friction, *for Hyatt Roller Bearings!* Because Hyatt Roller Bearings function so smoothly, so friction-free, so enduringly that they are adding daily to greater progress and, in addition, are making possible new standards of engineering design and excellence.

For all bearing requirements Hyatts outlast the mechanism of which they are a part . . . Because they are built to inconceivably precise standards of workmanship . . . Because they are made of the finest bearing steel . . . Because they are built to stand up under punishing speeds and loads. Consult the Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Detroit, San Francisco, or Hyatt Roller Bearing Sales Company, Chicago and Pittsburgh.

HYATT  **ROLLER BEARINGS**

PRESSURE DROP, LB. PER SQ. IN. PER MILE OF 4-IN. PIPE LINE (OIL OF 30° A.P.I.)

Quantity of 30° A.P.I. oil, bbl. per hr.	Viscosity of oil, Saybolt Universal seconds										
	100	110	120	130	140	150	160	180	200	220	240
100	15.05	15.49	15.91	16.30	16.68	17.03	17.35	17.94	18.50	18.97	19.42
105	16.37	16.87	17.30	17.72	18.13	18.51	18.87	19.52	20.14	20.65	21.13
110	17.77	18.31	18.78	19.23	19.66	20.08	20.46	21.17	21.84	22.40	22.93
115	19.20	19.76	20.28	20.77	21.23	21.67	22.08	22.86	23.58	24.19	24.76
120	20.67	21.28	21.85	22.34	22.84	23.31	23.77	24.61	25.35	26.04	26.63
125	22.17	22.83	23.45	23.99	24.49	25.00	25.50	26.39	27.20	27.92	28.57
130	23.74	24.44	25.08	25.67	26.21	26.76	27.27	28.22	29.10	29.88	30.58
135	25.38	26.10	26.79	27.42	28.01	28.58	29.11	30.14	31.09	31.93	32.69
140	27.04	27.79	28.52	29.22	29.85	30.44	31.00	32.09	33.09	33.99	34.81
145	28.74	29.54	30.29	31.04	31.72	32.33	32.94	34.08	35.14	36.11	36.99
150	30.46	31.35	32.12	32.93	33.63	34.31	34.93	36.12	37.27	38.28	39.21
155	32.25	33.19	34.02	34.85	35.60	36.32	36.96	38.21	39.40	40.51	41.51
160	34.11	35.12	35.97	36.86	37.63	38.40	39.08	40.41	41.62	42.80	43.87
165	35.99	37.03	37.97	38.85	39.67	40.49	41.21	42.62	43.88	45.14	46.27
170	37.90	39.00	40.00	40.90	41.77	42.64	43.40	44.87	46.21	47.51	48.71
175	39.84	41.01	42.07	43.02	43.94	44.82	45.64	47.19	48.57	49.92	51.19
180	41.81	43.08	44.20	45.17	46.14	47.04	47.90	49.55	51.01	52.39	53.74
185	43.87	45.21	46.40	47.42	48.41	49.36	50.27	51.97	53.51	54.93	56.36
190	45.93	47.35	48.60	49.68	50.68	51.68	52.64	54.43	56.02	57.52	58.98
195	48.07	49.52	50.83	52.02	53.03	54.08	55.05	56.93	58.60	60.18	61.68
200	50.23	51.71	53.10	54.34	55.41	56.51	57.53	59.47	61.22	62.88	64.41
205	52.46	53.97	55.47	56.73	57.90	59.01	60.08	62.12	63.96	65.66	67.21
210	54.74	56.27	57.79	59.12	60.39	61.56	62.63	64.77	66.70	68.44	70.06
215	57.00	58.60	60.20	61.59	62.92	64.15	65.27	67.46	69.48	71.30	73.01
220	59.28	61.01	62.69	64.14	65.48	66.77	67.94	70.17	72.30	74.20	75.98
225	61.65	63.46	65.10	66.67	68.08	69.42	70.65	72.98	75.15	77.13	79.00
230	64.01	65.97	67.62	69.33	70.73	72.20	73.42	75.86	78.12	80.14	82.10
235	66.50	68.48	70.20	71.99	73.45	74.92	76.26	78.74	81.04	83.21	85.18
240	68.96	71.02	72.82	74.61	76.21	77.67	79.13	81.66	84.05	86.31	88.38
245	71.44	73.59	75.53	77.26	78.99	80.52	81.97	84.67	87.10	89.46	91.60
250	73.94	76.18	78.20	80.00	81.81	83.39	84.91	87.65	90.25	92.63	94.86
255	76.58	78.84	80.94	82.82	84.69	86.34	87.92	90.77	93.40	95.88	98.21
260	79.22	81.56	83.75	85.70	87.57	89.37	90.93	93.89	96.55	99.12	101.54
265	81.88	84.32	86.59	88.53	90.48	92.34	93.96	97.04	99.80	102.48	104.91
270	84.66	87.10	89.37	91.47	93.41	95.34	97.11	100.31	103.09	105.86	108.39
275	87.38	89.91	92.27	94.45	96.46	98.46	100.21	103.53	106.41	109.29	111.91
280	90.25	92.79	95.14	97.49	99.58	101.57	103.47	106.91	109.90	112.79	115.51
285	93.03	95.65	98.18	100.53	102.69	104.75	106.72	110.19	113.28	116.28	119.10
290	95.92	98.64	101.26	103.59	105.82	107.86	110.00	113.59	116.79	119.80	122.72
295	98.75	101.66	104.28	106.69	109.00	111.11	113.32	117.03	120.35	123.46	126.38
300	101.70	104.61	107.31	109.91	112.19	114.37	116.56	120.50	123.93	127.05	130.06
305	104.61	107.73	110.52	113.10	115.57	117.72	119.97	124.05	127.60	130.82	133.93
310	107.51	110.84	113.61	116.27	118.94	121.16	123.37	127.59	131.25	134.58	137.80
315	110.54	113.97	116.84	119.59	122.22	124.63	126.80	131.16	134.94	138.37	141.69
320	113.48	117.14	120.09	122.93	125.53	128.01	130.26	134.87	138.77	142.20	145.63
325	116.55	120.33	123.38	126.31	128.99	131.55	133.86	138.50	142.52	146.18	149.59
330	119.70	123.60	126.74	129.76	132.52	135.16	137.55	142.20	146.35	150.13	153.65
335	122.82	126.84	130.08	133.06	136.04	138.76	141.22	146.02	150.16	154.18	157.68
340	125.98	129.98	133.45	136.52	139.59	142.26	144.93	149.73	154.13	158.14	161.74
345	129.15	133.27	136.98	140.00	143.16	145.91	148.66	153.60	158.14	162.26	165.83
350	132.53	136.63	140.45	143.56	146.82	149.65	152.48	157.43	162.24	166.34	170.16
355	135.75	139.97	144.05	147.25	150.45	153.36	156.27	161.36	166.16	170.53	174.46
360	139.15	143.33	147.52	150.82	154.11	157.10	160.09	165.33	170.27	174.75	178.79
365	142.41	146.72	151.03	154.56	157.79	160.87	163.95	169.33	174.40	179.02	183.17
370	145.86	150.28	154.55	158.19	161.50	164.82	167.83	173.36	178.57	183.31	187.58
375	149.21	153.76	158.14	162.04	165.29	168.70	171.78	177.46	182.82	187.69	192.08
380	152.71	157.38	161.88	165.72	169.22	172.72	175.72	181.55	187.05	192.06	196.56
385	156.06	161.02	165.47	169.58	173.17	176.59	179.67	185.83	191.31	196.44	201.06
390	159.60	164.52	169.08	173.47	177.16	180.67	183.83	189.98	195.60	200.86	205.43
395	163.17	168.22	172.90	177.40	181.18	184.61	188.03	194.33	199.91	205.32	210.00
400	167.00	171.99	176.79	181.22	185.29	188.61	192.31	198.59	204.31	209.86	214.66

"They keep coming back for more"

In 1938—as in past years—mile after mile of Armco Spiral Welded Pipe is going in for transmission and gas gathering lines. What's more, the biggest share of this growing demand is *repeat business*—"the proof of the pudding."

Why do so many oil and gas companies prefer Armco Pipe? Chiefly because they can get it *quickly* in small or large quantities, and in a wide assortment of wall thicknesses. Then too, this strong, easy-handling pipe reduces installation and field-welding costs because we supply it in exact 40-foot lengths with bevelled ends.

Once you try Armco Spiral Welded Pipe we feel confident that you too will "come back for more." Address your inquiries and specifications to: The American Rolling Mill Co., Pipe Sales Division, Middletown, Ohio; 538 Mayo Bldg., Tulsa, Okla.; 3500 Maury St., Houston, Texas.

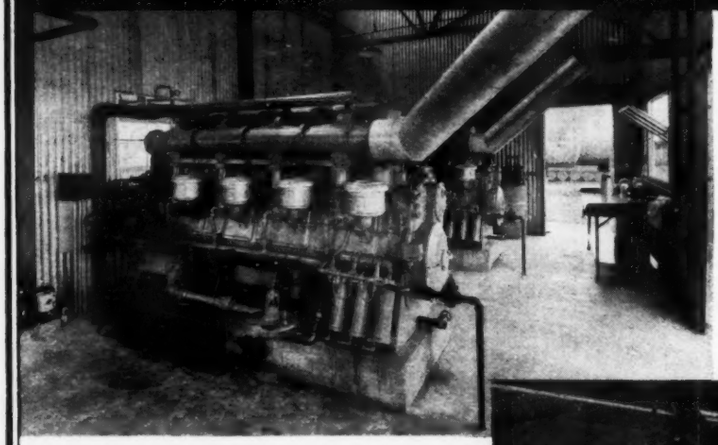
ARMCO SPIRAL WELDED PIPE

THEORETICAL CAPACITY OF RECIPROCATING PUMPS, GAL. PER MIN. PER CYLINDER

Displacement, gal. per stroke per cylinder[1]	Pumping speed, strokes[2] (revolutions) per min.										
	25	30	35	40	45	50	55	60	75	100	125
0.560	14.00	16.80	19.60	22.40	25.20	28.00	30.80	33.60	42.00	56.00	70.00
0.570	14.25	17.10	19.95	22.80	25.65	28.50	31.35	34.20	42.75	57.00	71.25
0.580	14.50	17.40	20.30	23.20	26.10	29.00	31.90	34.80	43.50	58.00	72.50
0.590	14.75	17.70	20.65	23.60	26.55	29.50	32.45	35.40	44.25	59.00	73.75
0.600	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	45.00	60.00	75.00
0.620	15.50	18.60	21.70	24.80	27.90	31.00	34.10	37.20	46.50	62.00	77.50
0.640	16.00	19.20	22.40	25.60	28.80	32.00	35.20	38.40	48.00	64.00	80.00
0.660	16.50	19.80	23.10	26.40	29.70	33.00	36.30	39.60	49.50	66.00	82.50
0.680	17.00	20.40	23.80	27.20	30.60	34.00	37.40	40.80	51.00	68.00	85.00
0.700	17.50	21.00	24.50	28.00	31.50	35.00	38.50	42.00	52.50	70.00	87.50
0.720	18.00	21.60	25.20	28.80	32.40	36.00	39.60	43.20	54.00	72.00	90.00
0.740	18.50	22.20	25.90	29.60	33.30	37.00	40.70	44.40	55.50	74.00	92.50
0.760	19.00	22.80	26.60	30.40	34.20	38.00	41.80	45.60	57.00	76.00	95.00
0.780	19.50	23.40	27.30	31.20	35.10	39.00	42.90	46.80	58.50	78.00	97.50
0.800	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00	60.00	80.00	100.00
0.820	20.50	24.60	28.70	32.80	36.90	41.00	45.10	49.20	61.50		
0.840	21.00	25.20	29.40	33.60	37.80	42.00	46.20	50.40	63.00		
0.860	21.50	25.80	30.10	34.40	38.70	43.00	47.30	51.60	64.50		
0.880	22.00	26.40	30.80	35.20	39.60	44.00	48.40	52.80	66.00		
0.900	22.50	27.00	31.50	36.00	40.50	45.00	49.50	54.00	67.50		
0.920	23.00	27.60	32.20	36.80	41.40	46.00	50.60	55.20	69.00		
0.940	23.50	28.20	32.90	37.60	42.30	47.00	51.70	56.40	70.50		
0.960	24.00	28.80	33.60	38.40	43.20	48.00	52.80	57.60	72.00		
0.980	24.50	29.40	34.30	39.20	44.10	49.00	53.90	58.80	73.50		
1.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00	75.00		
1.20	30.00	36.00	42.00	48.00	54.00	60.00	66.00	72.00	90.00		
1.40	35.00	42.00	49.00	56.00	63.00	70.00	77.00	84.00	105.00		
1.60	40.00	48.00	56.00	64.00	72.00	80.00	88.00	96.00	120.00		
1.80	45.00	54.00	63.00	72.00	81.00	90.00	99.00	108.00	135.00		
2.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00			
2.20	55.00	66.00	77.00	88.00	99.00	110.00	121.00	132.00			
2.40	60.00	72.00	84.00	96.00	108.00	120.00	132.00	144.00			
2.60	65.00	78.00	91.00	104.00	117.00	130.00	143.00	156.00			
2.80	70.00	84.00	98.00	112.00	126.00	140.00	154.00	168.00			
3.00	75.00	90.00	105.00	120.00	135.00	150.00	165.00	180.00			
3.20	80.00	96.00	112.00	128.00	144.00	160.00	176.00	192.00			
3.40	85.00	102.00	119.00	136.00	153.00	170.00	187.00	204.00			
3.60	90.00	108.00	126.00	144.00	162.00	180.00	198.00	216.00			
3.80	95.00	114.00	133.00	152.00	171.00	190.00	209.00	228.00			
4.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00			
4.20	105.00	126.00	147.00	168.00	189.00	210.00	231.00	252.00			
4.40	110.00	132.00	154.00	176.00	198.00	220.00	242.00	264.00			
4.60	115.00	138.00	161.00	184.00	207.00	230.00	253.00	276.00			
4.80	120.00	144.00	168.00	192.00	216.00	240.00	264.00	288.00			
5.00	125.00	150.00	175.00	200.00	225.00	250.00	275.00	300.00			

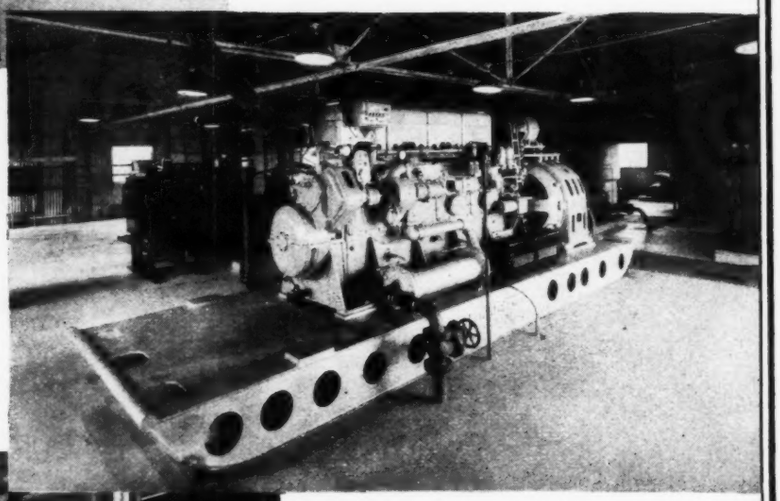
[1]Table P 094.865, Sheets 1 and 2, pp. 123, 125, July, 1937.
[2]For double-acting pumps make sure that the "displacement" value used is the total for both ends of the pump.

"ECONOMICAL AND SATISFACTORY SERVICE"

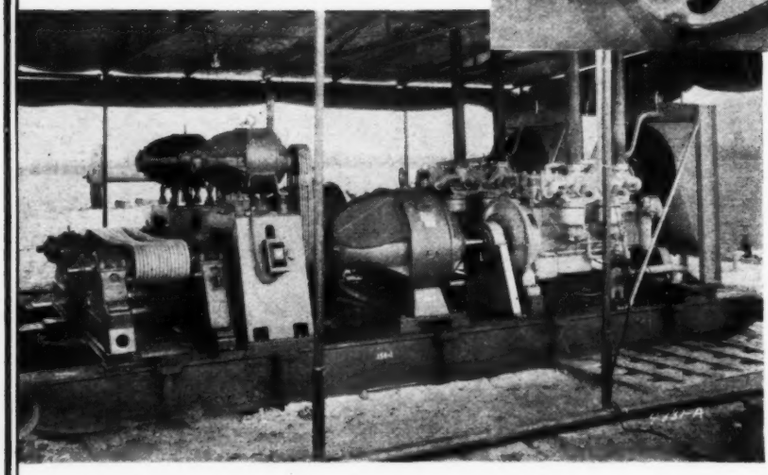


The above is quoted from a prominent Pipe Line Company with authority to use these pictures of pipe line pumping engines, on continuous duty at 900 R. P. M., 320 H. P. load, 400 H. P. maximum.

2-Sterling Viking 8-cylinder 320-400 H.P. Butane engines.



200 K. W. Generator Set, Sterling Viking 8-cylinder 320 - 400 H. P. Natural Gas engine.



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